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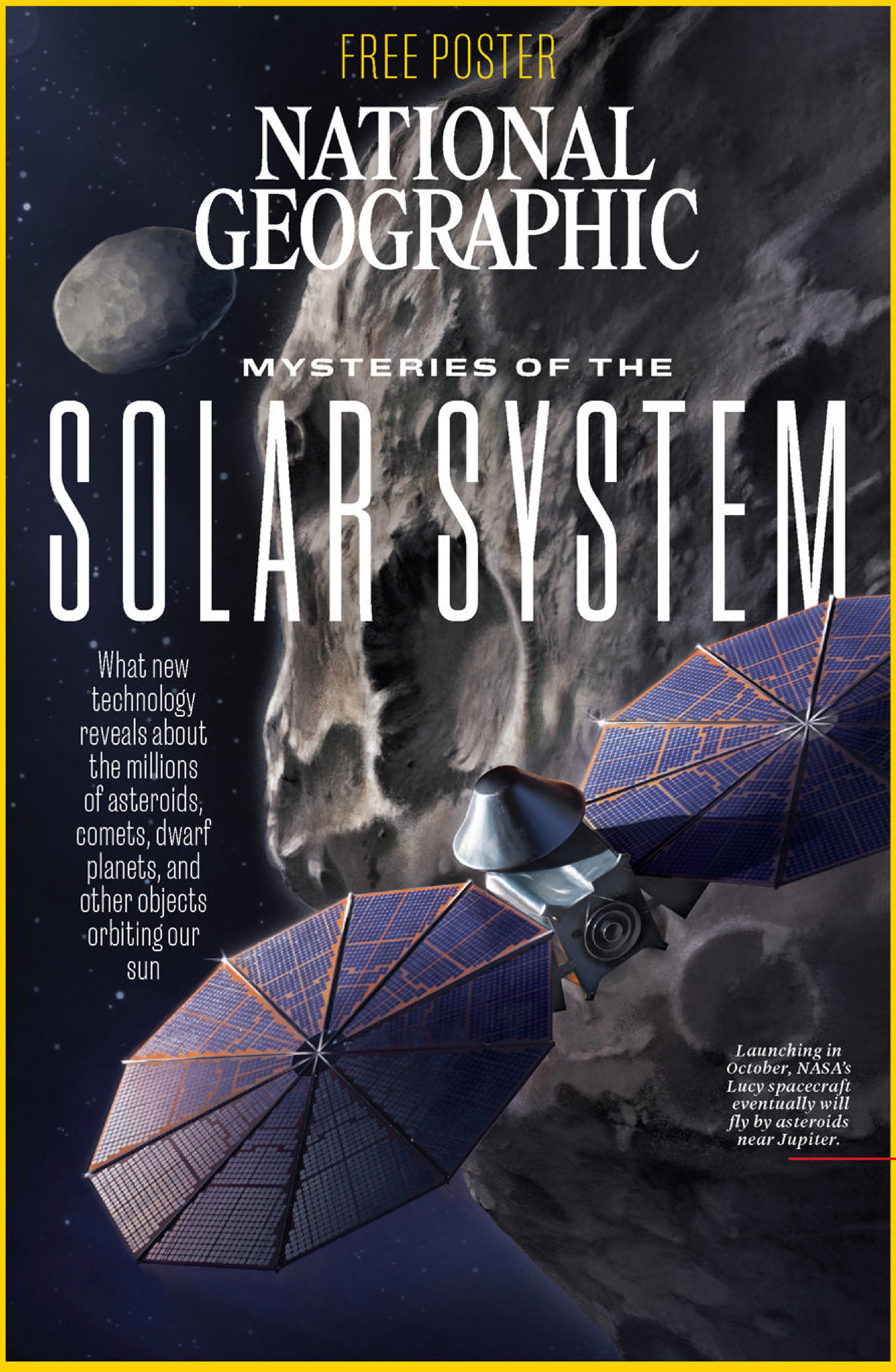

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MYSTERIES OF THE

# SOLAR SYSTEM

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*Launching in October, NASA's Lucy spacecraft eventually will fly by asteroids near Jupiter.*

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SEPTEMBER 2021

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ASTEROID 3D RENDER:
RONALD PANIAGUA

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21PGAD09

20 YEARS AFTER 9/11

# Pausing to Remember

BY **SUSAN GOLDBERG**

**IF YOU'RE AGE 30** or older, you probably remember what you were doing when you heard about the events of September 11, 2001. It's one of those indelible, where-were-you moments, like the attack on Pearl Harbor or the Kennedy assassination for earlier generations.

This month, we commemorate the 20th anniversary of "9/11"—that instantly recognizable, vastly inadequate shorthand to describe a day that killed nearly 3,000 people and launched the longest war in modern U.S. history.

Two stories in this issue explore 9/11. One's an on-the-ground report from Afghanistan. The other features still life photography of seemingly ordinary objects—a pair of boots, a watch, a snapshot—that aren't ordinary at all. These objects, some never before displayed, came from the rubble of the World Trade Center in New York, a field in Shanksville, Pennsylvania, and the Pentagon in Arlington, Virginia. Those were the sites where al Qaeda terrorists crashed hijacked planes, instantly creating a frightening new world.

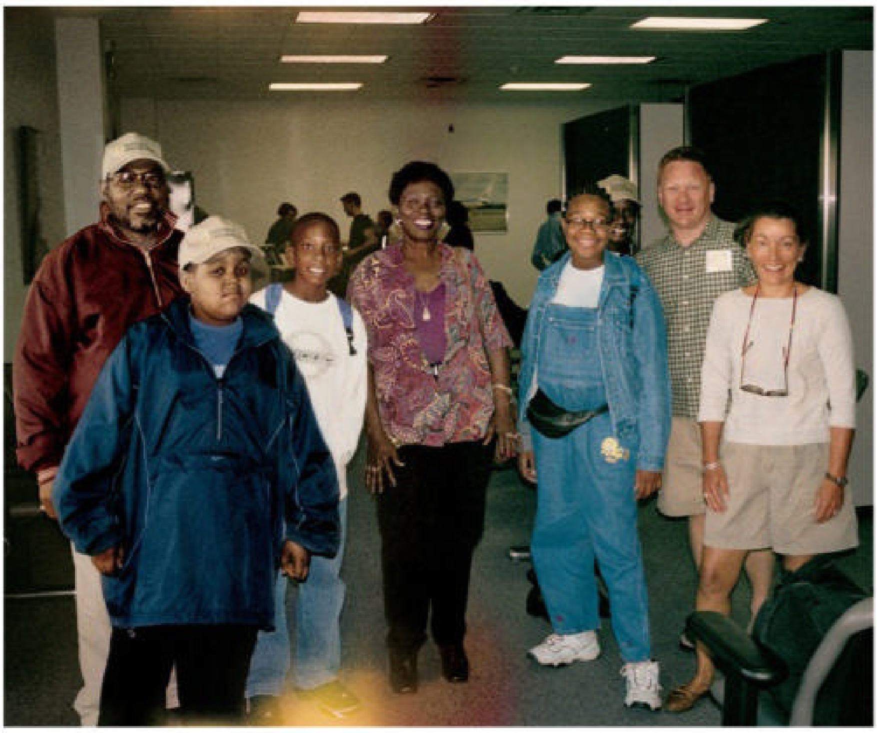
The plane that hit the Pentagon was American Airlines Flight 77, bound for Los Angeles. At 9:37 a.m., five hijackers slammed it into the building's west side, killing themselves, 59 others aboard, and 125 on the ground. Among the dead were eight people traveling to an ecology conference sponsored by National Geographic. Every year on September 11, at our Washington, D.C., headquarters, we pause to remember them.

Three of the National Geographic travelers were 11 years old: Bernard Brown, Asia Cottom, and Rodney Dickens, each with a future whose promise would never be realized. Each child had been selected to attend the conference. Each child, according to tributes written at the time, was smart, determined, kindhearted. Today, when Bernard, Asia, and Rodney would be 31 years old, it's devastating to think of our collective loss.

On 9/11 we also lost three caring teachers: Sara Clark, James Debeuneure, and Hilda Taylor, who accompanied the students. Sara, 65, and her fiancé were making wedding arrangements. James, 58, a father and grandfather, enjoyed golf and collecting art. Hilda, 58, a mother and grandmother, loved to cook and work in her garden.

The others whose passing we mourn were National Geographic employees. Ann Judge, 49, arranged trips around the world for our journalists and executives; Joe Ferguson loved teaching children about geography. He was 39.

We salute those we lost 20 years ago with this quote from the Pentagon 9/11 Memorial: "We claim this ground in remembrance of the events of September 11, 2001. To honor the 184 people whose lives were lost, their families, and all who sacrifice that we may live in freedom. We will never forget." ◻



Members of the group traveling with National Geographic pause in Dulles International Airport for a photo before their flight. From left to right: James Debeuneure, Rodney Dickens, Bernard Brown, Hilda Taylor, Asia Cottom, Joe Ferguson, and Ann Judge.

PHOTO: GWEN FAULKNER

ATEM Mini Pro model shown.

# Introducing ATEM Mini Pro

## The compact television studio that lets you create presentation videos and live streams!

Blackmagic Design is a leader in video for the television industry, and now you can create your own streaming videos with ATEM Mini. Simply connect HDMI cameras, computers or even microphones. Then push the buttons on the panel to switch video sources just like a professional broadcaster! You can even add titles, picture in picture overlays and mix audio! Then live stream to Zoom, Skype or YouTube!

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ATEM Mini's includes everything you need. All the buttons are positioned on the front panel so it's very easy to learn. There are 4 HDMI video inputs for connecting cameras and computers, plus a USB output that looks like a webcam so you can connect to Zoom or Skype. ATEM Software Control for Mac and PC is also included, which allows access to more advanced "broadcast" features!

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ATEM Mini is really a professional broadcast switcher used by television stations. This means it has professional effects such as a DVE for picture in picture effects commonly used for commentating over a computer slide show. There are titles for presenter names, wipe effects for transitioning between sources and a green screen keyer for replacing backgrounds with graphics.

### Live Stream Training and Conferences

The ATEM Mini Pro model has a built in hardware streaming engine for live streaming via its ethernet connection. This means you can live stream to YouTube, Facebook and Teams in much better quality and with perfectly smooth motion. You can even connect a hard disk or flash storage to the USB connection and record your stream for upload later!

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With so many cameras, computers and effects, things can get busy fast! The ATEM Mini Pro model features a "multiview" that lets you see all cameras, titles and program, plus streaming and recording status all on a single TV or monitor. There are even tally indicators to show when a camera is on air! Only ATEM Mini is a true professional television studio in a small compact design!

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# PROOF

NATIONAL GEOGRAPHIC

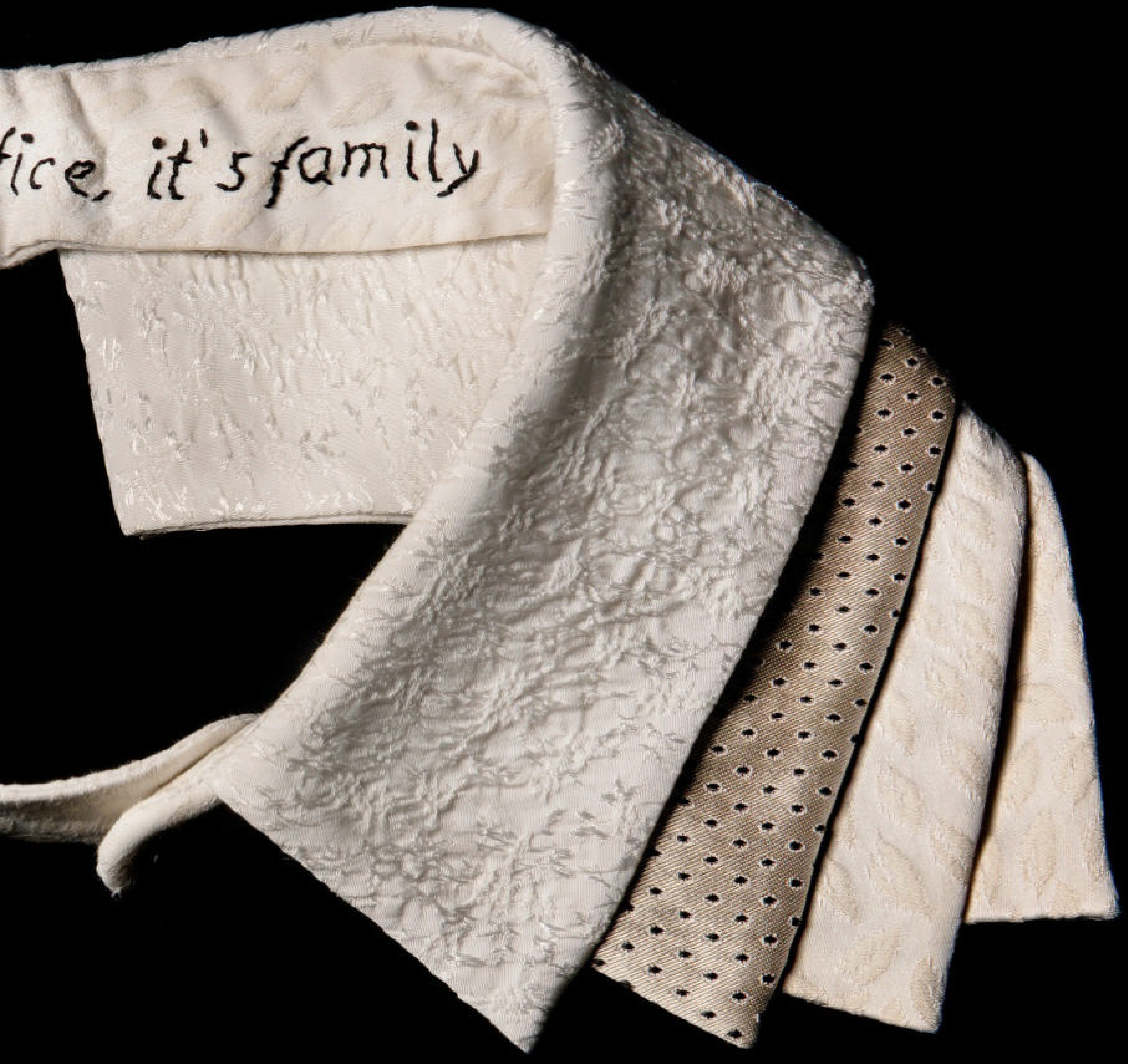
PHOTOGRAPHS BY **ELINOR CARUCCI**

LOOKING AT THE EARTH FROM EVERY POSSIBLE ANGLE

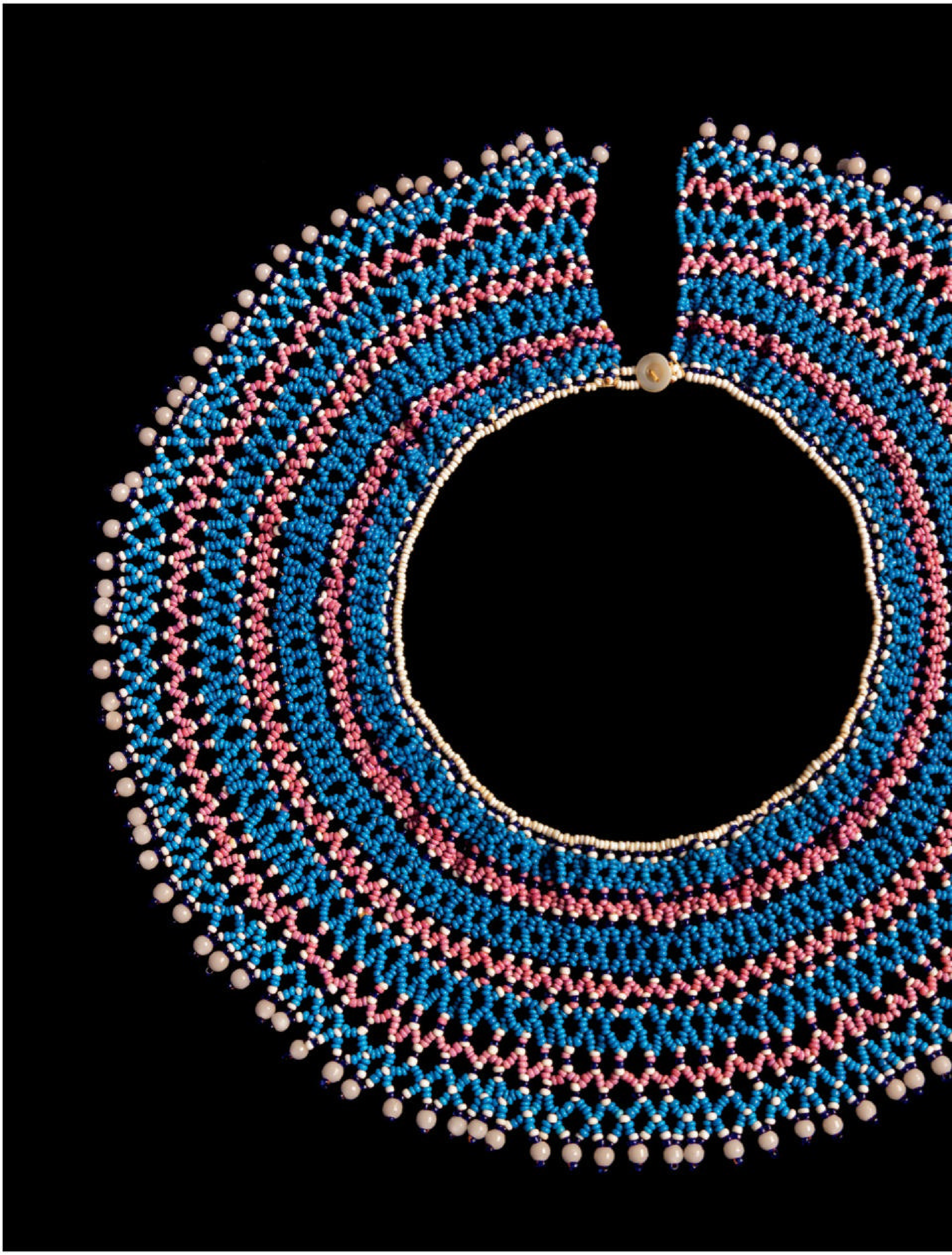
# COLLARS OF CONVICTION

Her robe accessories were just one way Justice Ruth Bader Ginsburg stood out on the high court.

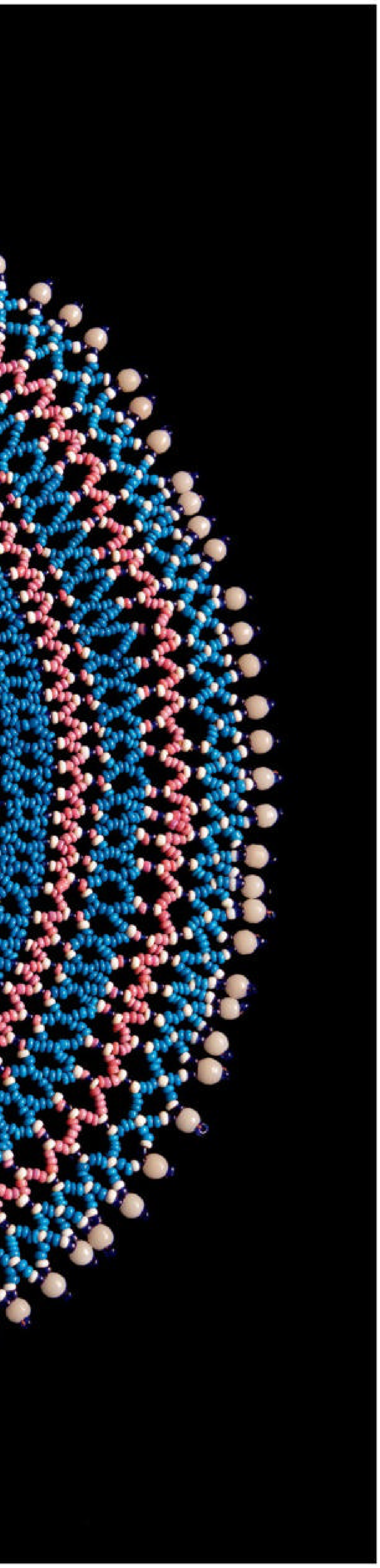
VOL. 240 NO. 3

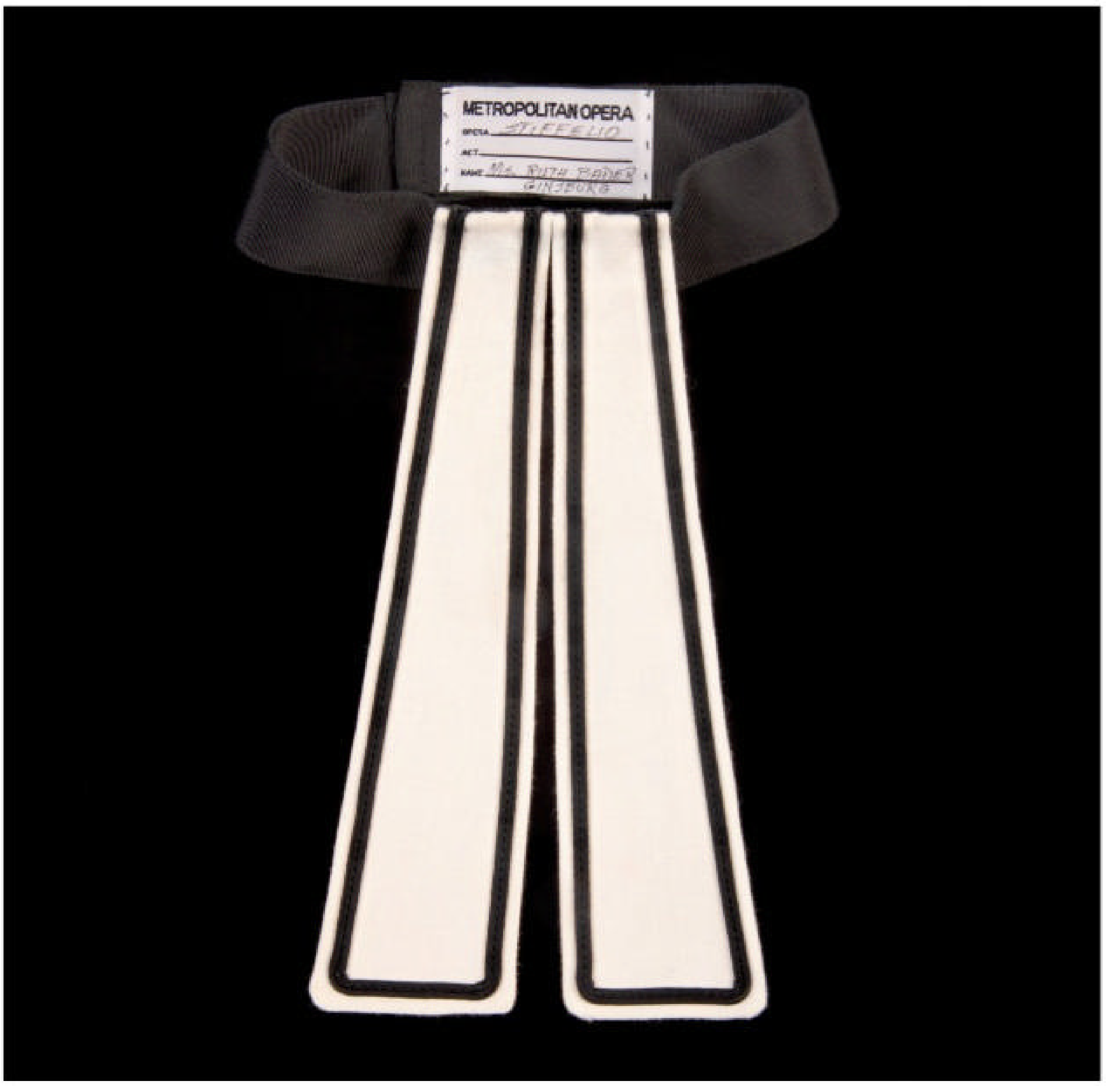


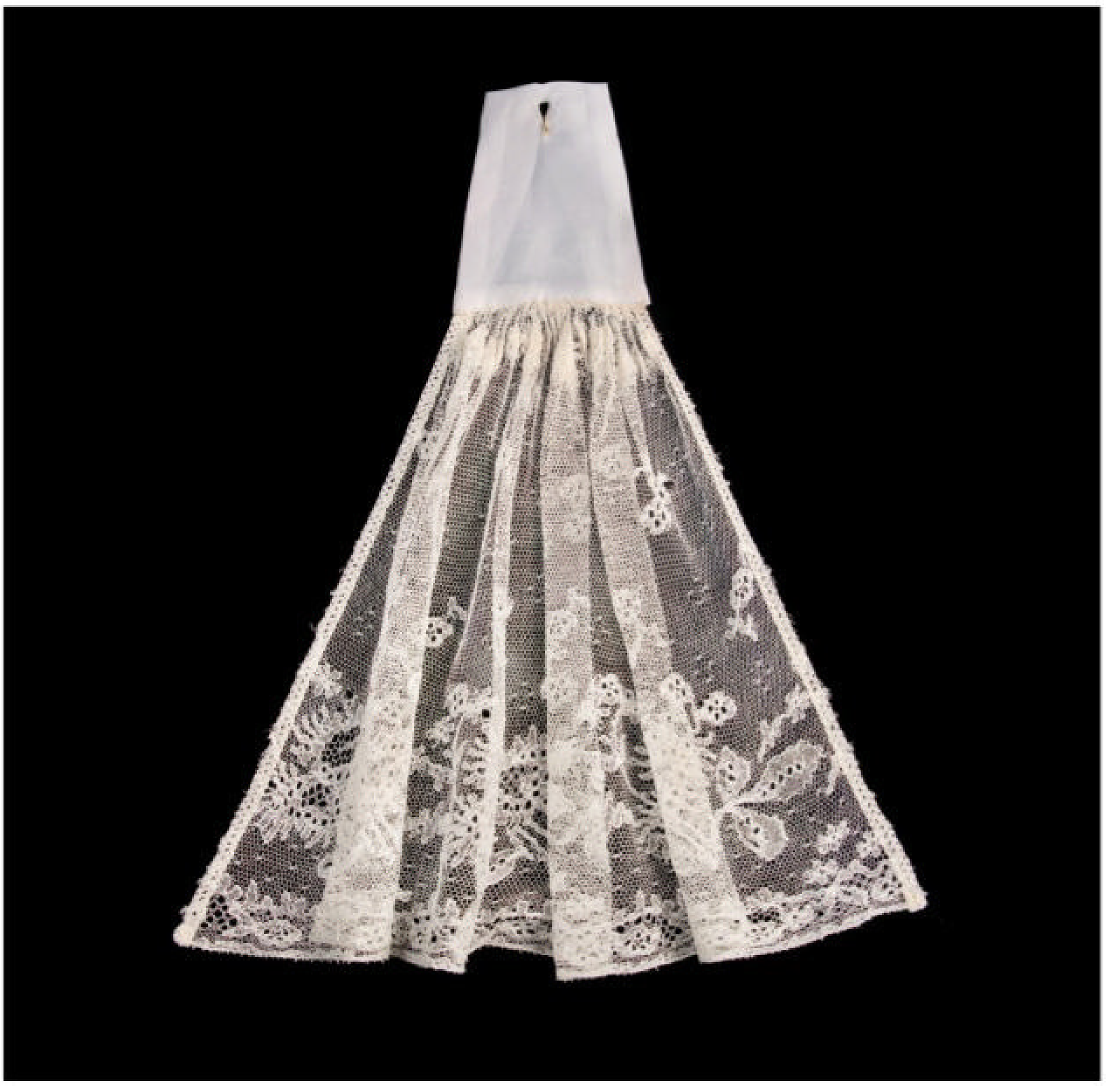
This collar made for the late Ruth Bader Ginsburg is imbued with personal meaning: Each of the four layers of fabric represents one member of her immediate family.



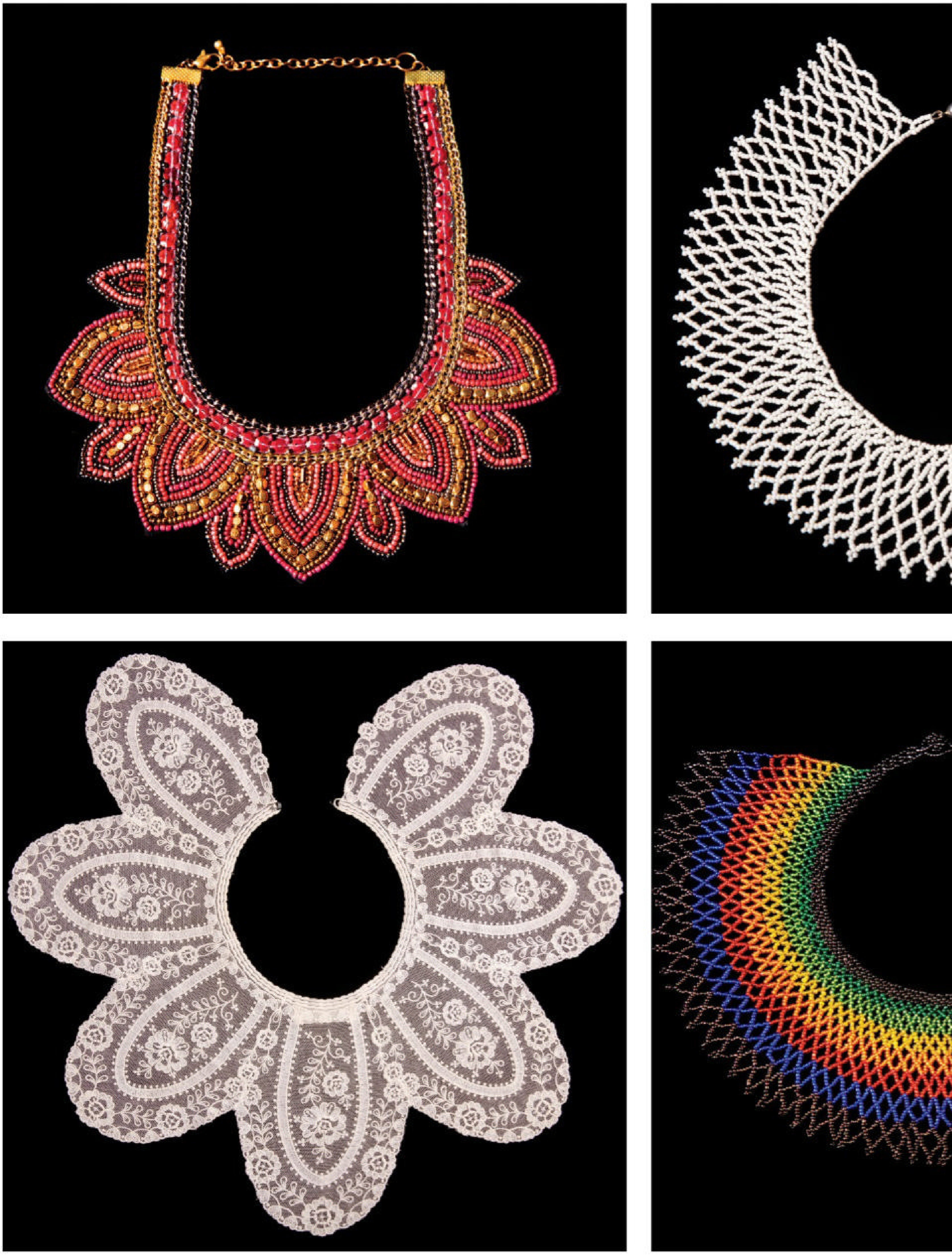
Left: Ginsburg wore this pink-and-blue beaded collar, a gift from women's groups at Georgetown University Law Center, to President Barack Obama's 2015 State of the Union address. Top right: Ginsburg was a fan of opera; this is a copy of a jabot



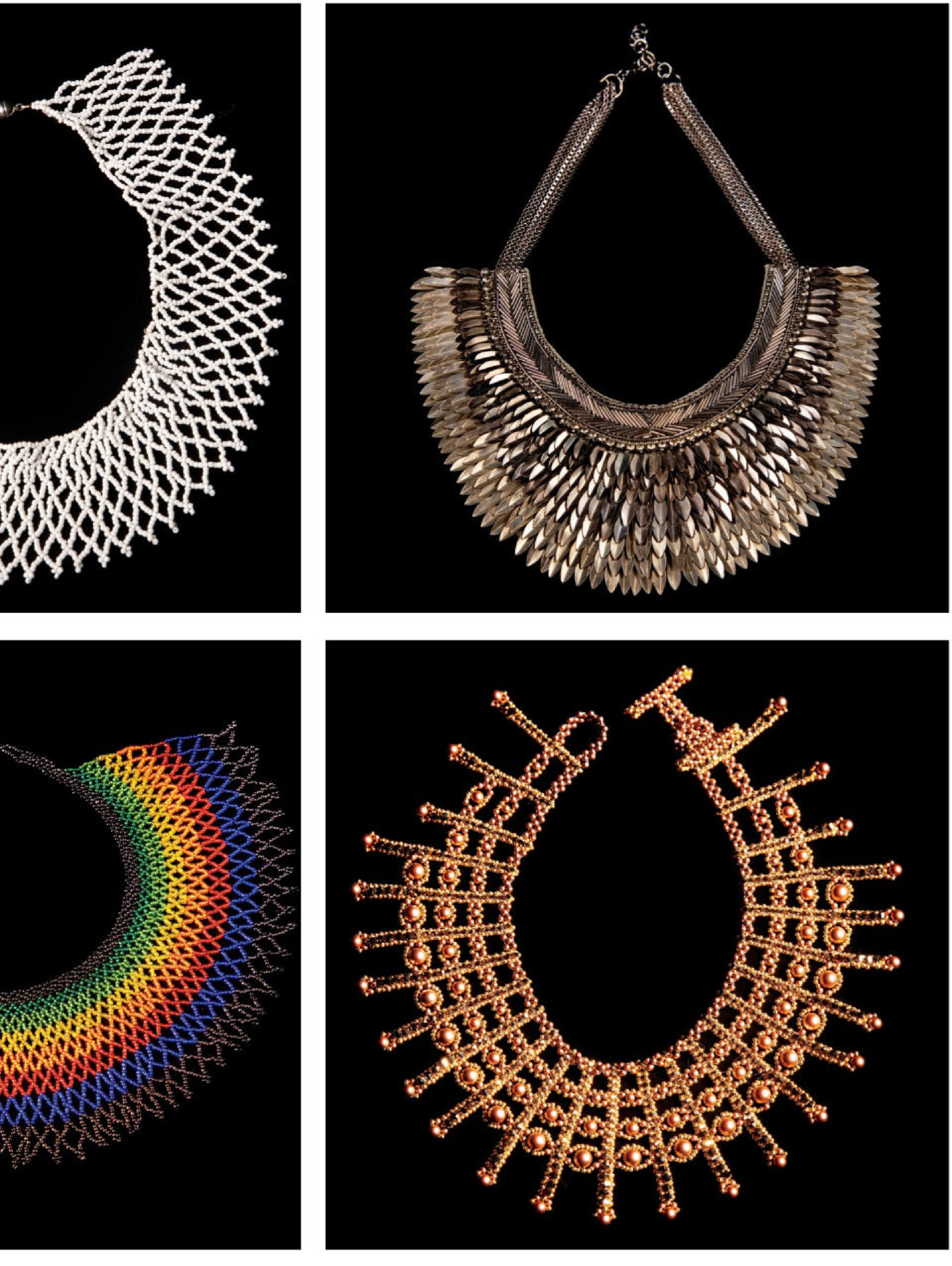




worn by opera singer Plácido Domingo, from the Metropolitan Opera gift shop. Bottom right: One of Ginsburg's original lace jabots, which she frequently wore on the bench between 1993 and 2008 and in official portraits.



Clockwise from top left: Ginsburg sometimes wore this vibrant red-and-gold collar, a thank-you gift from a staff member, to weddings; a white-beaded South African collar, said to be Ginsburg's favorite; a spiky metal piece worn in the first official



Court portrait with Justice Brett Kavanaugh in 2018; a gold-and-purple collar the justice considered to be elegant; a rainbow pride collar from Ecuador that Ginsburg first wore in 2016; and a doily-like lace collar, a gift.

# THE BACKSTORY

ON ASSIGNMENT AT THE SUPREME COURT, A PHOTOGRAPHER TRIES TO DO JUSTICE TO A JUSTICE'S FASHION TRADEMARK.

**ARRIVING AT** the U.S. Supreme Court to photograph a collection of Ruth Bader Ginsburg's iconic collars less than two months after the justice's death, Elinor Carucci was nervous but prepared. Knowing she'd have roughly six minutes to make images of each collar, Carucci had spent the previous day photographing makeshift replicas she cut from paper towels. Carucci says her goal was to capture the vibrancy and character of the cherished Ginsburg accessories: "It really was like looking at pieces of history."

The delicate collar that made Carucci cry is embroidered with a quote from Ginsburg's husband, Martin: "It's not sacrifice, it's family." For Carucci, it reflects the many facets of the justice's identity: wife, mother, Jewish daughter of immigrants, second woman on the high court. Balancing disparate roles, Carucci notes, "is something so many of us women struggle with."

To Carucci, an Israeli immigrant and mother of a queer child, the collars—one in rainbow pride colors—are ripe with meaning: "Emotional and personal and political and so many things at once." —**NATASHA DALY**

Ruth Bader Ginsburg served on the high court from 1993 until her death in September 2020.

TIMOTHY GREENFIELD-SANDERS, CONTOUR RA BY GETTY IMAGES

# EXPLORE

**IN THIS SECTION**
Fossilized Feather
Under Tahiti's Waves
Historic Wigmaking
Invasives on the Menu

ILLUMINATING THE MYSTERIES—AND WONDERS—ALL AROUND US EVERY DAY
**NATIONAL GEOGRAPHIC** **VOL. 240 NO. 3**

# The Story of Human Difference

### RACE IS A SOCIAL CONSTRUCT, NOT A BIOLOGICAL TRAIT. THAT'S THE SCIENTIFIC CONSENSUS—SO WHY DO MANY STILL DOUBT IT?

BY **ANGELA SAINI**

**ORIGIN TALES EXIST** everywhere. In the United States there is the myth of Manifest Destiny, that European settlers were preordained to spread west across America. In China the remains of *Homo erectus* known as Peking man are used to claim an unbroken Chinese lineage going back at least 700,000 years, with suggestions that this was a direct ancestor and among the first in the world to harness fire.

In India religious nationalists have suggested that fantastical legends as described in old Hindu epics aren't allegories but actually happened. One prominent Indian scientist has even said that the tale of a woman who gave birth to a hundred children is testament to ancient Indian skill in advanced reproductive technologies that are only now being rediscovered.

One of Donald Trump's parting shots before leaving the presidency was to create an advisory panel called the 1776 Commission, to promote his vision of a "patriotic education" in the United States. The commission's report downplayed the realities of discrimination and deliberate human exploitation in the nation's founding. It took particular aim at scholars and activists who call attention to historical injustice as part of addressing modern-day inequality.

Trump's effort was short-lived because President Joe Biden disbanded the commission the day he was sworn in. But the culture wars weren't over—Trump wasn't the first political leader to try to claim the past for his own ends, and he won't be the last. Visit national museums or monuments anywhere in the world and you will see triumphalist displays that paint countries in their best light, serving narratives of greatness often wrapped in notions of ethnic or racial superiority. To respond in these times, we must decide what stories we really want to tell about ourselves and who we are.

**THE BELIEF IN DEEP-ROOTED** population difference is among the most well-worn of political tools. The Nazis in Germany sought to define a Germanic people, building a case for racial exceptionalism. Not just history but biology and archaeology too have long been recruited into efforts to emphasize group difference, selling populations the illusion that they are naturally better than others.

Over time, these stories can become woven into identity in subtle and insidious ways, embedding themselves into our understanding of who we are. They can distort the way even today's scientists think about human difference.

The history of race is a reminder that science isn't just about theories and data; it's also about which facts are recruited into the stories we tell about human variation. European Enlightenment naturalists and scientists once decided that humans might be divided into discrete groups in the same way as some other animal species, before arbitrarily setting the boundaries for these categories. They attached meaning to skin color, using sweeping cultural stereotypes about temperament, intelligence, and behavior. These pseudoscientific ideas went on to inform Western medicine for centuries. They formed the basis for the Nazi eugenics program of racial cleansing and the Holocaust.

Although it has been known for at least 70 years that race is undeniably a social construct and that those 18th-century thinkers were misguided in their assumptions, many scientists still labor under the belief that race is biologically real. The story embedded itself so firmly that even when it became clear that we are one genetically indivisible human species, it remained difficult for many researchers to look beyond it. The old narrative looms too large in their imaginations.

The rise and fall of racial myths during the COVID-19 pandemic have been a case in point. Social media speculation in early 2020 that Black people couldn't catch the virus morphed just a few months later into the claim that they were more susceptible to it. Scientists themselves fanned these flames of

## Biological Differences: Myths Linger

When scientists insisted in one of the world's leading medical journals, the *Lancet,* in May 2020 that "genetic make-up" could be a possible factor in the varying COVID-19 outcomes seen among ethnic groups at the time, they echoed a strain of thinking that has persisted through medical literature for centuries. In 1793, when a yellow fever epidemic hit Philadelphia, white physicians claimed that Black people were naturally immune. In 2016 a study of around 200 medical students and residents published by researchers at the University of Virginia found that around half held at least one belief about "biological differences between Blacks and whites, many of which are false and fantastical in nature." They included the myths that Black people have a higher tolerance for pain and have thicker skin. **—AS**

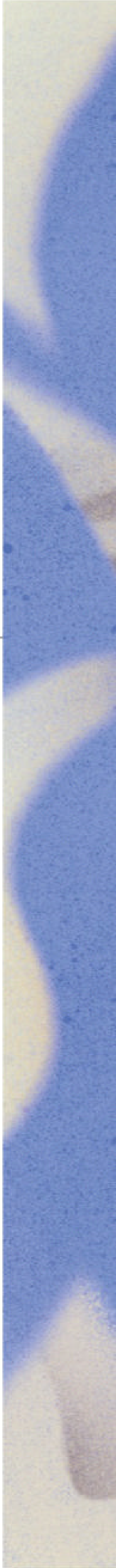


ILLUSTRATION: TRACY J. LEE

misinformation by wondering out loud whether genetic differences between races might have played a role in mortality rates despite there being next to no data to support that assertion. Social determinants of health, including poverty, geography, and occupation, were woefully overlooked.

That was, until the murder of George Floyd in the spring of 2020. Suddenly there was a palpable shift in the narrative around race and health.

The scientific facts remained the same: Race was as much a social construct as it ever was. But now there was a global conversation on what race really meant and how the explicit and implicit effects of racism so viscerally impact the body. Physicians, I noticed, began to call for more research on socioeconomic status, diet, toxic environments, and prejudice in health care. I was invited to speak about my work on bias in science at medical schools and scientific institutions across the globe.

These developments prove that the political environment has enormous influence on the questions scientists ask and the answers they give. When the backdrop to our human story is one of natural group difference, researchers inevitably will look to genetics and innate factors first. But when that backdrop has more historical context, showing race to be a product of social factors, the focus instead swings to how groups of people live and how they're treated. That subtle realignment helps us to diagnose the problem where it is rather than where we might imagine it to be.

**WE ARE STILL IN A BATTLE** over the story of human difference. Far-right groups and ethnic nationalists scour scientific journals for scraps of evidence they can cherry-pick to support their claims that the course of human history has been decided by genetically stronger races and that social inequality today is simply a product of these innate differences between populations.

Only recently, two papers published in the early 1990s by a controversial Canadian psychologist were retracted from the journal *Psychological Reports* after editors realized that the work was "unethical, scientifically flawed, and based on racist ideas and agenda." Similarly deficient papers are under review by that journal and others. But when the errors are this egregious, one has to wonder what has taken scientific publishers quite so long. Equally, we need to ask how they managed to get published in the first place. Perhaps it comes down to the stories that some scientists want to believe, even in the face of undeniable evidence.

SCIENTISTS NEED TO BE CAREFUL ABOUT WHICH OVERARCHING NARRATIVE THEY SERVE. IS IT ONE THAT EMPHASIZES THE ESSENTIAL UNITY OF OUR SPECIES?

Academics often claim that they are led by data, not by politics. But it's interesting to note just how much politics has shaped how scientists think about human difference. It's no coincidence, for example, that eugenics as a serious discipline deflated after World War II, thanks to efforts by antiracists within science and anthropology. Neither is it by chance that some of the most blatant falsehoods about women's minds and bodies began to be debunked from the 1970s onward, riding a wave of feminist scholarship.

But of course, there are always those who will want to retain the old stories. In a world in which populism and ethnic nationalism are on the rise, that's to be expected. Our origin stories, our traditional ways of seeing the world, can feel like security blankets in troubled times. We may cling to them against our better judgment. For those who feel they have the most to lose from racial, class, and gender equality—whose lives have been cushioned by social injustice rather than damaged by it—there's no incentive to change the narrative.

Scientists need to be careful about which overarching narrative they serve. Is it one that emphasizes the essential unity of our species? Reminding us, for instance, that we are genetically more alike than any other primate species and that individual difference far outweighs any group difference? Or is it one that searches in the margins of our genomes for the tiny statistical differences between populations, consciously or unconsciously playing to those who seek to divide us in other ways?

The facts may be the same either way, but it's the story we tell ourselves that matters.

**Angela Saini** is a British science journalist, broadcaster, and the author of books including *Superior: The Return of Race Science.*

## Unfinished work

Historical legacies of race science and eugenics live on in many modern-day institutions. But efforts are under way to reframe the past, correct mistakes, and make science more inclusive. —AS

**Fund to be reformed**
For decades, the UC Berkeley School of Public Health benefited from a research fund originally created to study eugenics. The school says the fund will be repurposed to repudiate its past, perhaps by establishing an antiracist institute.

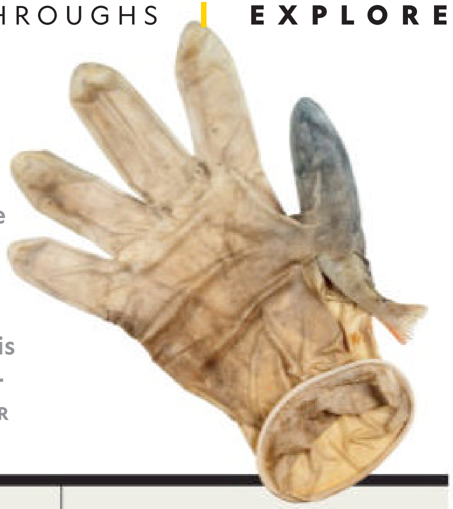
**Name changed**
Health-care network MSI Reproductive Choices rebranded in 2020 so it's no longer named for Marie Stopes (1880-1958). Over time, her support for family planning and women's rights has been eclipsed by her support of eugenics.

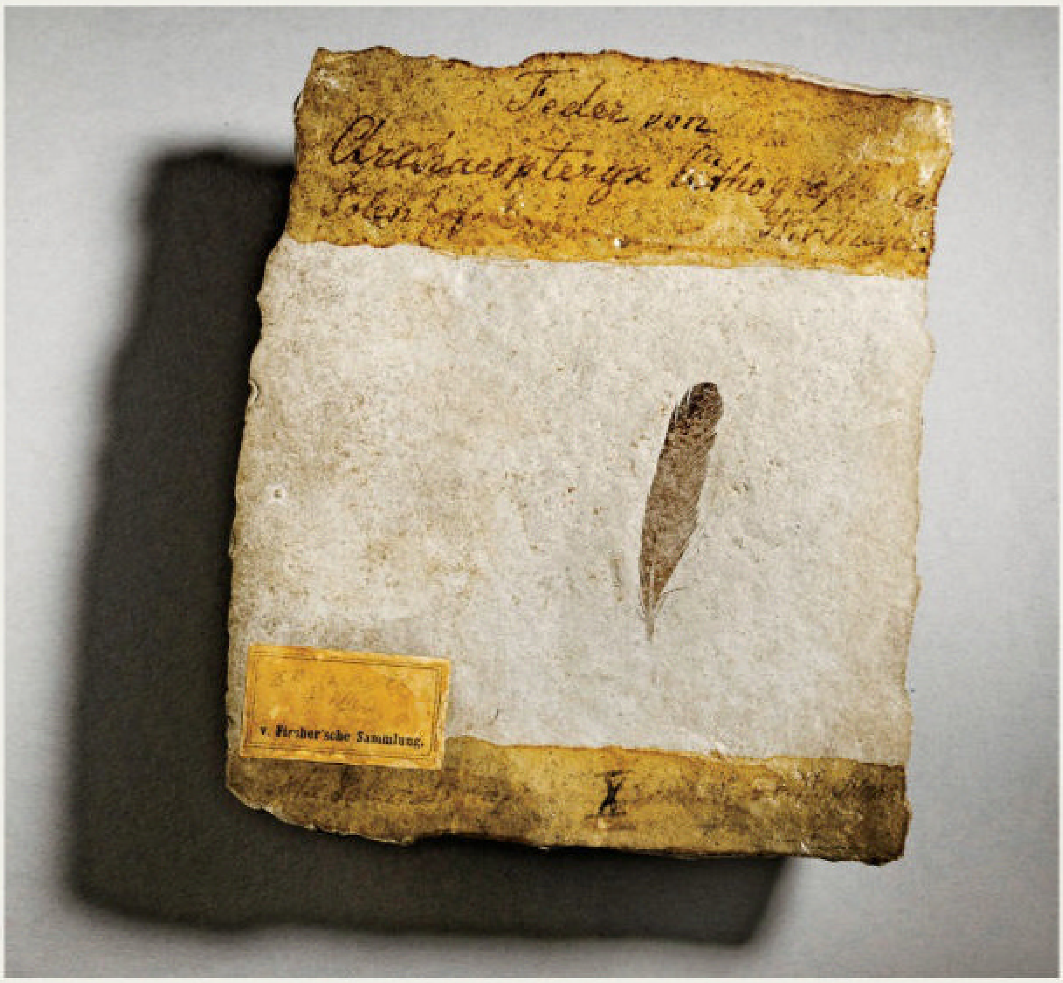
**Repatriation planned**
A University of Pennsylvania museum apologized for possessing skulls (some from enslaved people) that a 19th-century doctor unethically acquired and used to claim whites' supremacy. The museum aims to return the skulls to "ancestral communities."

**DISPATCHES
FROM THE FRONT LINES
OF SCIENCE
AND INNOVATION**

### PPE Where It Shouldn't Be

The fight against COVID-19 has had environmental costs. Mountains of personal protective equipment have been discarded—at one point, an estimated 3.4 billion masks a day. What shielded humans now harms wildlife, like the perch trapped in this glove in the Netherlands and countless birds snared in mask straps. —AR





PALEONTOLOGY

# FROM A DINO'S WINO?

**ON THE 160TH ANNIVERSARY OF THE DISCOVERY OF THIS FOSSILIZED FEATHER, SCIENTISTS ARE STILL INVESTIGATING THE DINOSAUR IT ADORNED.**

**SINCE IT EMERGED** from a Bavarian limestone quarry in 1861, the first known fossilized feather has been a paleontology icon: shockingly similar to modern bird feathers yet unfathomably ancient. The 150-million-year-old, isolated plume was the first fossil ever called *Archaeopteryx lithographica*—a name that now refers to a type of feathered dinosaur discovered less than two miles away in the same rock layers as the original feather. But did *Archaeopteryx* the dinosaur really shed its namesake feather? National Geographic Explorer Ryan Carney, a paleontologist at the University of South Florida, says the answer is a resounding yes. In a paper published last fall in *Scientific Reports,* Carney contends that the feather not only belonged to an *Archaeopteryx* but also specifically helped form the upper surface of the dinosaur's left wing. Now Carney is reconstructing how *Archaeopteryx* flapped its wings, to test whether it could have flown under its own power. —MICHAEL GRESHKO

PLANT LIFE

## A Magnetic Charge in Its Chomp

When the Venus flytrap's jawlike leaves are stimulated by prey, the plant produces a small magnetic field, new research has found. Such fields have been detected in only two other plants: a bean and a single-celled alga. The scientists who discovered this field think it's a by-product of electrical impulses that trigger the flytrap's leaves to close. Biomagnetism of this type has been studied extensively in the human brain but is less understood in plants. —ANNIE ROTH

PHOTOS (FROM TOP): AUKE-FLORIAN HIEMSTRA; MUSEUM FÜR NATURKUNDE BERLIN; PAUL STAROSTA, GETTY IMAGES

# BRAVE THE WAVE

In French Polynesia, waves are revered and feared at the legendary

**SOME OF THE WORLD'S** heaviest waves crash along the reef of Teahupoo, on the southeastern coast of Tahiti. The power of these barrels explains the small village's selection as the venue for the 2024 Olympic surfing competition, but it's also a place of dramatic beauty and rich culture.

### A WILD RIDE

The barrier reef rises from dizzying depths at Teahupoo's Passe Havae; it has the perfect shape and location to amplify Pacific Ocean swells. These can become the thundering surges known as plunging waves. May through October is the best time to catch the action, but exceptional surf rolls in year-round. For this image, photographer Andy Bardon went below the surface. "A deep breath and calm nerves are required to safely dive under and photograph these waves," he says. But then "a biodiverse underworld reveals itself."

### SURF AND TURF

**On water:** Visitors hire local water taxis for up-close views of expert surfers riding the waves—as well as glimpses of dolphins and, August through October, humpback whales. Not far from the black sand beach, snorkelers can explore colorful coral gardens.

**On land:** A sandy trail beyond the Tirahi Rivière meanders past brightly painted houses to a palm-shaded point where families picnic and surfers begin their paddle out to the break.

### MORE TO EXPLORE

Boat tours take in the remote Fenua Aihere and Te Pari coastlines adjacent to Teahupoo. Here travelers find waterfalls that tumble into the sea, caves linked to Polynesian legend, and paths leading to ancient petroglyphs. To help protect the ecosystem and boost fish populations, locals have designated a roughly three-square-mile marine zone around Teahupoo to be under *rahui,* a traditional Polynesian fishing and harvesting ban.

NGM MAPS

surf break off the village of Teahupoo.

> ‘SURFING TEAHUPOO FEELS LIKE BATTLING TWO GIANTS, WITH THE MOUNTAINS ON ONE SIDE AND THE OCEAN BREAKING ON THE OTHER.’
>
> —*Michel Bourez, Tahitian Olympic surfer*

**BY THE NUMBERS**

**1**

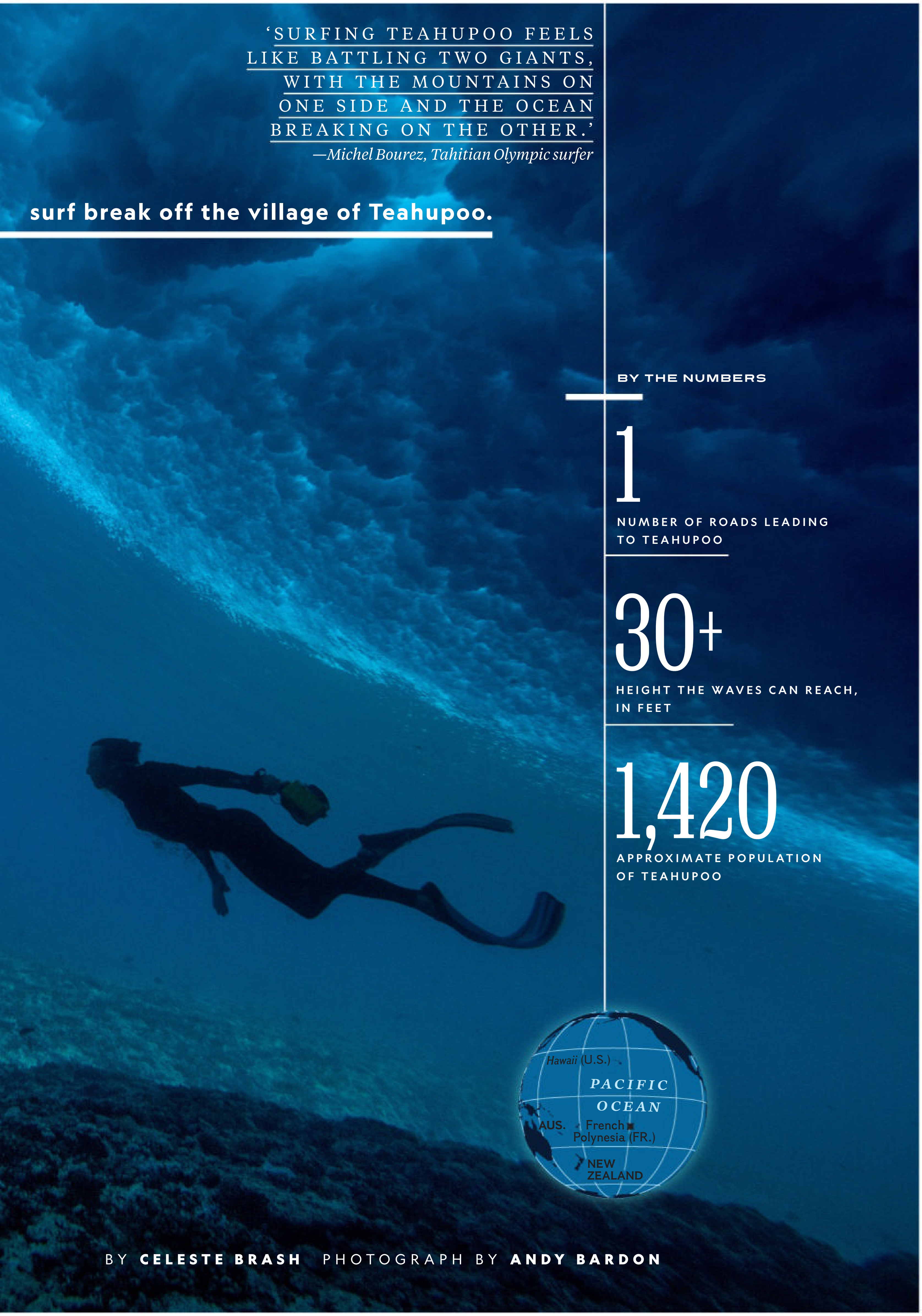
NUMBER OF ROADS LEADING TO TEAHUPOO

**30+**

HEIGHT THE WAVES CAN REACH, IN FEET

**1,420**

APPROXIMATE POPULATION OF TEAHUPOO



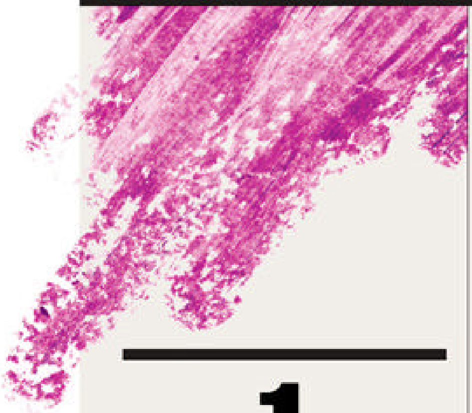
BY **CELESTE BRASH** PHOTOGRAPH BY **ANDY BARDON**

PLANET POSSIBLE

For more stories about how to help the planet, go to *natgeo.com/planet*

# Send kids into the school year with eco-friendly ideas for their lunches, supplies, and projects.

BY **ALLYSON SHAW**



## 1

WRITE CHOICES

**Three green tips for coloring, drawing**

**1.** Store pens, markers, and highlighters topside down to keep the tips moist.

**2.** Look for supplies that use recycled materials—colored pencils made from old newspapers or mechanical pencils created from recovered plastic.

**3.** Most crayons contain petroleum and don't easily biodegrade—so save broken bits for another use. You could melt them down in the oven to create cool color combos, or mail them to a group that recycles crayons, such as *crazycrayons.com*.

## 2

SHOP YOUR HOUSE

RUMMAGE IN DRAWERS AT HOME FOR USABLE MARKERS, SCISSORS, AND NOTEBOOKS BEFORE BUYING NEW ONES. STILL MISSING SOME ITEMS? CHECK STATIONERY SHOPS AND BOOKSTORES FOR PACKAGING-FREE SCHOOL SUPPLIES.

## 3

LUNCH BOOST

**Yes to taste, no to waste**

Got picky eaters? Bring your kids to the grocery store and let them choose their own snacks—fresh fruit, trail mix, popcorn, banana chips—from produce or bulk food sections where foods aren't wrapped.

## 4

BOTTLE GOALS

**About a million plastic beverage bottles are sold every minute around the world. Equip your kids with personal reusable water bottles they can take to school, sports, and activities. And if their school isn't already recycling plastic bottles, consider talking to officials about how to start.**

## 5

TRIP TAKERS

**OUTINGS FOR AWARENESS**

Ask your child's teacher about a field trip to a landfill, recycling center, or creek. Seeing how waste is managed will encourage youngsters to recycle. And teaching them how to carefully observe nature builds environmental awareness.

PHOTOS: R. TSUBIN (1), FLOORTJE (2), ISABELLE ROZENBAUM (3), ANNA EFETOVA (4), GETTY IMAGES; LORI EPSTEIN, NATIONAL GEOGRAPHIC IMAGE COLLECTION (5)

INNOVATOR

# RAE WYNN-GRANT

BY **ANNIE ROTH** PHOTOGRAPH BY **REBECCA HALE**

## She tracks bears and promotes diversity in nature and science.

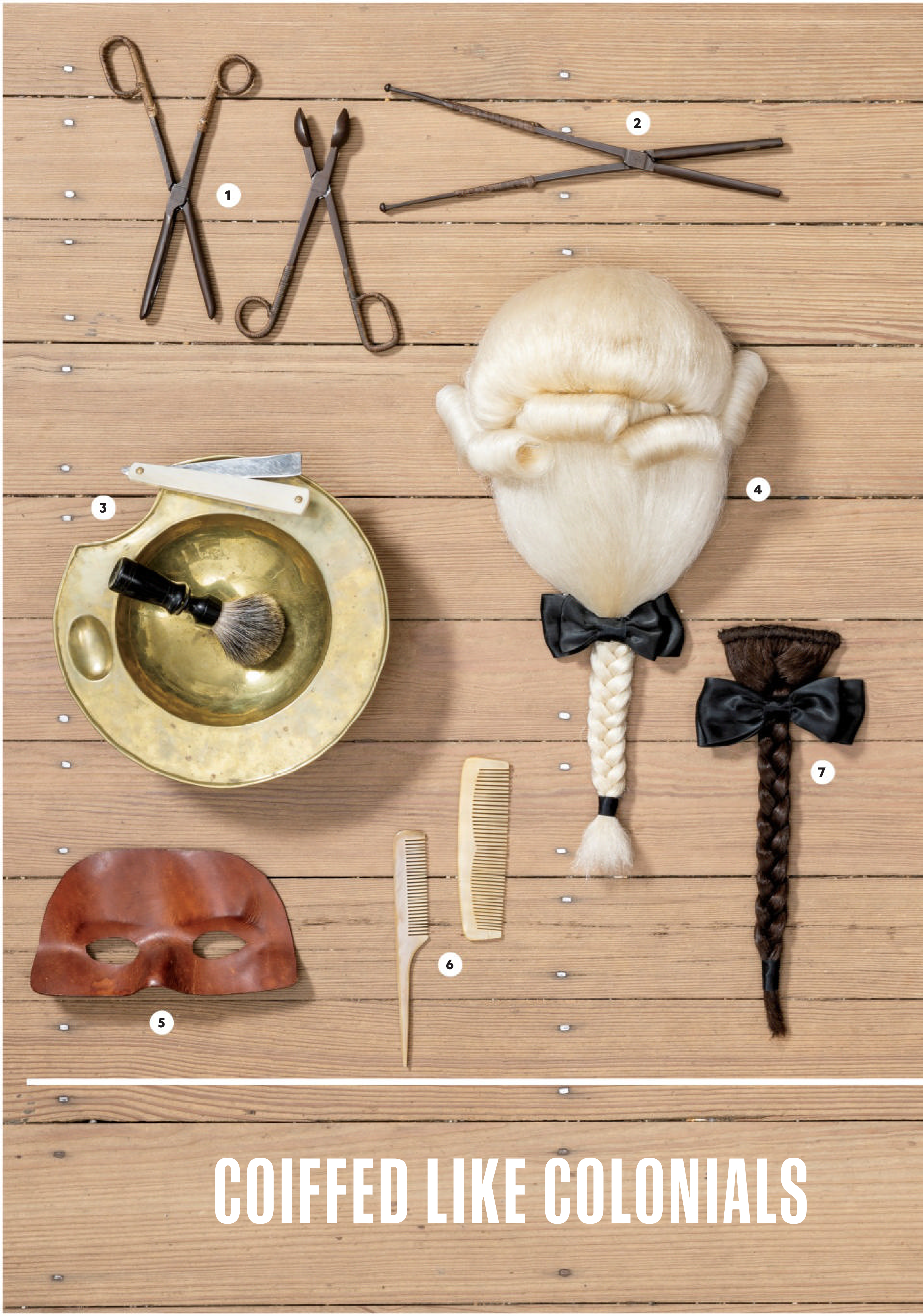
Rae Wynn-Grant wants people to know that bears aren’t bad news. The National Geographic Explorer focuses on ways to eliminate negative interactions between these charismatic carnivores and the humans living near bear habitat. Translating painstakingly collected data, she brings communities information about where bears are, where they’re traveling, and how locals can protect themselves.

In her work as a wildlife ecologist, she has also tracked lions across Tanzania and monitored ring-tailed lemurs in Madagascar. As her career progressed, Wynn-Grant, who is based in Santa Barbara, California, has grown stronger in her advocacy for the necessity of diversity in nature—and in the sciences.

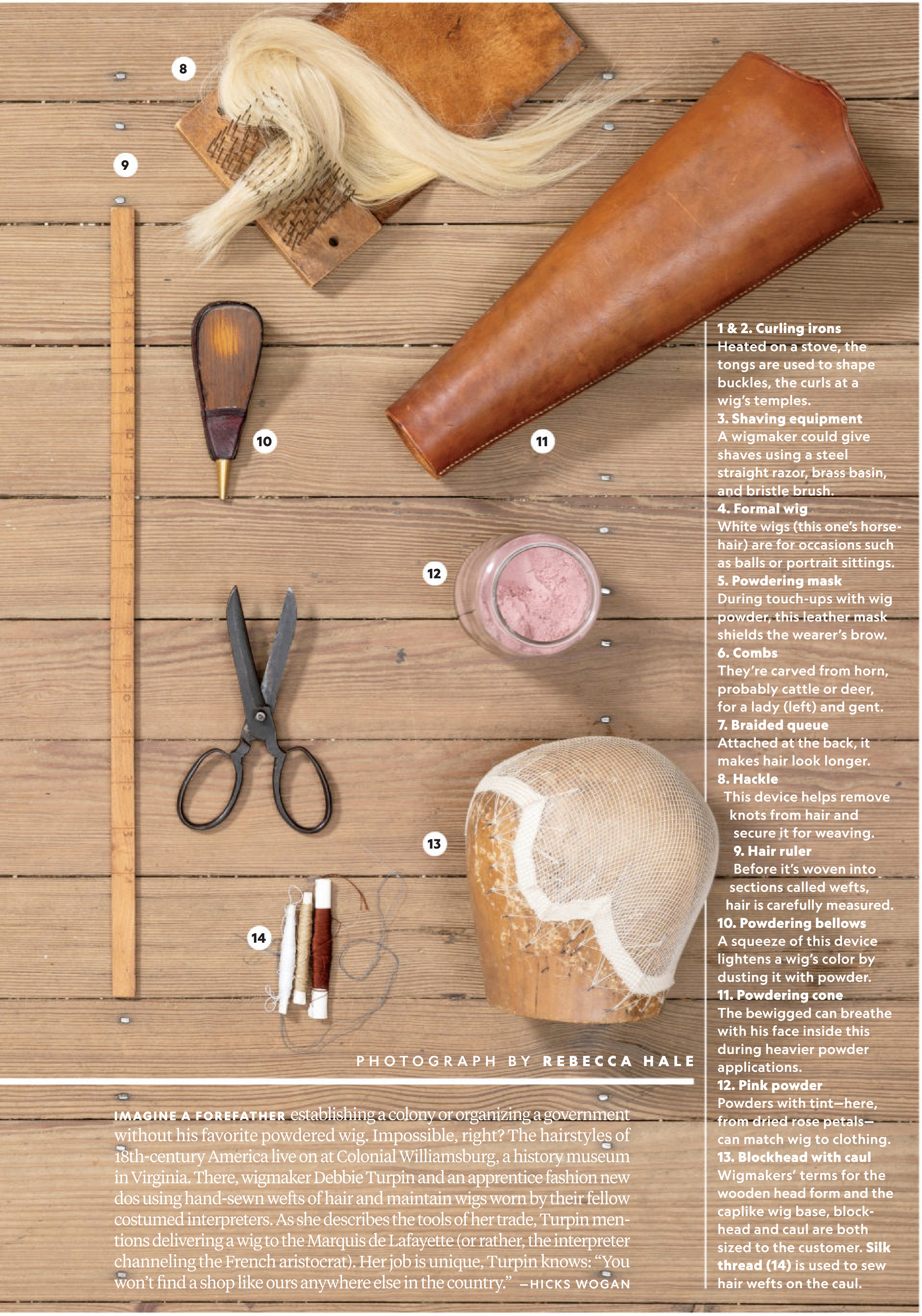
She was the lone Black person among her academic peers when she started studying wildlife ecology. The lack of diversity became only more obvious as she advanced in her field.

But she’s found that her success has inspired a new generation of aspiring ecologists of color. “I feel so much more hopeful about the future,” she says, “the future of wildlife, the future of the environment, the future of equity and justice and opportunity—because I’m seeing more people of color showing up in these spaces where I used to be the only one.”

**The National Geographic Society funds Wynn-Grant’s work. Learn more about its support of explorers protecting critical species at *natgeo.com/impact*.**



# COIFFED LIKE COLONIALS



PHOTOGRAPH BY REBECCA HALE

**IMAGINE A FOREFATHER** establishing a colony or organizing a government without his favorite powdered wig. Impossible, right? The hairstyles of 18th-century America live on at Colonial Williamsburg, a history museum in Virginia. There, wigmaker Debbie Turpin and an apprentice fashion new dos using hand-sewn wefts of hair and maintain wigs worn by their fellow costumed interpreters. As she describes the tools of her trade, Turpin mentions delivering a wig to the Marquis de Lafayette (or rather, the interpreter channeling the French aristocrat). Her job is unique, Turpin knows: “You won’t find a shop like ours anywhere else in the country.” —HICKS WOGAN

**1 & 2. Curling irons**
Heated on a stove, the tongs are used to shape buckles, the curls at a wig’s temples.

**3. Shaving equipment**
A wigmaker could give shaves using a steel straight razor, brass basin, and bristle brush.

**4. Formal wig**
White wigs (this one’s horsehair) are for occasions such as balls or portrait sittings.

**5. Powdering mask**
During touch-ups with wig powder, this leather mask shields the wearer’s brow.

**6. Combs**
They’re carved from horn, probably cattle or deer, for a lady (left) and gent.

**7. Braided queue**
Attached at the back, it makes hair look longer.

**8. Hackle**
This device helps remove knots from hair and secure it for weaving.

**9. Hair ruler**
Before it’s woven into sections called wefts, hair is carefully measured.

**10. Powdering bellows**
A squeeze of this device lightens a wig’s color by dusting it with powder.

**11. Powdering cone**
The bewigged can breathe with his face inside this during heavier powder applications.

**12. Pink powder**
Powders with tint—here, from dried rose petals—can match wig to clothing.

**13. Blockhead with caul**
Wigmakers’ terms for the wooden head form and the caplike wig base, blockhead and caul are both sized to the customer. **Silk thread (14)** is used to sew hair wefts on the caul.

The whole hog: Tamales are stuffed with wild boar meat, lard, and broth at Dai Due restaurant in Austin, Texas.

# EATING THE PROBLEM

FROM LIONFISH TO KUDZU, INVASIVE SPECIES—
USUALLY DESTRUCTIVE AND DISDAINED—CAN ALSO BE DELICIOUS.

BY **EVE CONANT**

**TWO WORDS THAT** don't look tempting on a menu? "Swamp" and "rat."

At least that's the dark-humored consensus among a literal boatload of chefs cruising along a Louisiana swamp just before the COVID-19 pandemic hit. They're touring at the invitation of local ecologists who want their help saving Louisiana's threatened wetlands. And the "swamp rat" is the invasive nutria, once imported from South America for its fur but now loose in the wild, chewing up so much habitat the state has a six-dollar-a-tail bounty on the rodent.

"Chefs here are our local celebrities," says Jacques Hebert of the Restore the Mississippi River Delta coalition. "Our culture revolves around eating." Perhaps conservation could too?

The South is hard-hit but hardly alone. The United States is home to more than 6,500 invasive species—non-natives that can reproduce aggressively, outcompete and spread disease to local species, and destroy habitat. Nutria may not be a crowd-pleaser, but a plethora of other invasive plants and animals are increasingly on chefs' radars.

The "invasivore" movement, while small, has its culinary and conservationist logic. Imagine a wild-foraging species that's not just "grass finished"—it's spent its life browsing organic habitat. Sprinkle in

PHOTO: JODY HORTON, *THE HOG BOOK*

Offer limited to the first 1400 orders from this ad only

Jewelry images enlarged to show luxurious color

*"We delight in the beauty of the butterfly, but rarely admit the changes it has gone through to achieve that beauty."*
— Positivity Sparkles.com

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THEN THERE ARE THE FERAL HOGS. WORRIED TEXAS OFFICIALS CALL THEM ‘OUTLAW QUADRUPEDS.’ CHEFS CALL THEM ‘WILD BOAR.’

some “micro-local” and “snout-to-hoof” chef-speak, and proponents say you have some serious starter ingredients for environmental stewardship.

Take lionfish, a damaging—and delicious—invasive. Native to the South Pacific and Indian Oceans, they were first spotted in the Atlantic Ocean in the 1980s. They’re overpopulating reefs and, without native predators, “fear nothing,” says spear fisherman and biologist Alex Fogg. He describes how they’re venomous, not poisonous, as we devour a tempura-fried, caramel-glazed, and beautifully plated specimen—one so outlandishly spiky it could double as a medieval weapon.

We’re at GW Fins, an upscale New Orleans restaurant whose chef that night, Tenney Flynn, had sent out an Instagram alert that lionfish was on the menu. “There’s a novelty factor,” he explains, checking to see how we also like the lionfish crudo with Fresno chili, kaffir lime, taro chips, and mint.

“There’s people who would never in a million years consider taking the life of a wild animal,” says Fogg. “But lionfish are something that those folks can get behind, because they’re helping the environment.” A vegan once told him that lionfish is the only animal she’d ever eat, “because of the cause.” Fogg runs an annual lionfish spearfishing tournament in Destin, Florida. This year’s winning team, Florida Man, got $10,000, and festivities included a restaurant week with lionfish as the star ingredient in fajitas, tacos, ceviches, and “Little Simba” sushi rolls.

Asian carp also infests and dominates waterways. Baton Rouge chef Philippe Parola, who runs a “Can’t Beat ’Em, Eat ’Em!” website devoted to invasives, is turning the carp into comfort food: premade and frozen fish balls that can be dropped into a deep fryer. He’s planning to target college cafeterias and stadiums for mass consumption. “We can’t wait,” he warns. “This had to be done yesterday.”

Perhaps the most infamous invasive is kudzu, the so-called “vine that ate the South.” It’s been smothering habitat since it was first formally introduced from Japan to the U.S. at the 1876 world’s fair in Philadelphia. Chef Matt Marcus has served kudzu pickled, dried, fermented—and fried, with pecans and browned butter—to diners in Atlanta. In the South, he jokes, “If we fry it, they’ll try it!”

The weed also inspires Gulf Shores, Alabama, chef Chris Sherrill of the NUISANCE Group, whose acronym stands for plants and animals that are a “Nuisance, Underutilized, or Invasive, but Sustainable and Available through Noble Culinary Endeavors.”

“Every chef in the Southeast could incorporate kudzu in a billion applications,” he says while serving it up in a pesto. “I sourced it off the road where I knew they hadn’t sprayed for pesticides, picked some off a telephone pole, put it in a food processor with olive and roasted acorns, lots of garlic, some sweet onions, and Parmesan cheese.”

Then there are the feral hogs. Worried Texas officials call them “outlaw quadrupeds.” Chefs call them “wild boar.” At Dai Due Butcher Shop and Supper Club in Austin, patrons pick up “certified boarganic” hog fat soap and dine among walls decorated with the skulls of nilgai—antelope imported for game hunting from India in the 1930s and now competing with native wildlife and cattle for grasses. Chef Jesse Griffiths leads feral hog butchery classes and hunts on ranches overrun with feral hogs, nilgai, and axis deer—another imported game-ranch escapee.

“Eating invasives is a great thing to do right now,” says Griffiths, as we chat over wild boar tacos and salami made of rich-tasting nilgai. He even has a recipe for “Chocolate Pig Cake” with hog lard. “It’s a rich flavor,” he says, and “highlights how much you can use a feral hog for.” He says many Texans poison the hogs, a torturous death with negative environmental effects. A swift hunt, he argues, is humane by comparison. “And every feral hog you eat or serve is also one less animal that you pull out of an industrial agriculture situation.”

He knows it’s not a perfect solution. “There was some ecologist who said it right—we’re not gonna barbecue our way out of this.” But that doesn’t diminish the allure. These invasive species are “incredibly destructive—and highly edible.” □

**Eve Conant** is a staff writer and editor for *National Geographic*.

## Wild Flavors

Invasive species from feral hogs and kudzu to lionfish (left to right) are increasingly gracing southern tables. Other parts of the country too are embracing the cause with events such as cook-offs featuring nutria in Oregon and invasive-crayfish boils around the Great Lakes.

PHOTOS, LEFT TO RIGHT: MARTIN DEMMEL, TONY L. MOORE, FEDERICO CABELLO, GETTY IMAGES (ALL)

SEPTEMBER 2021

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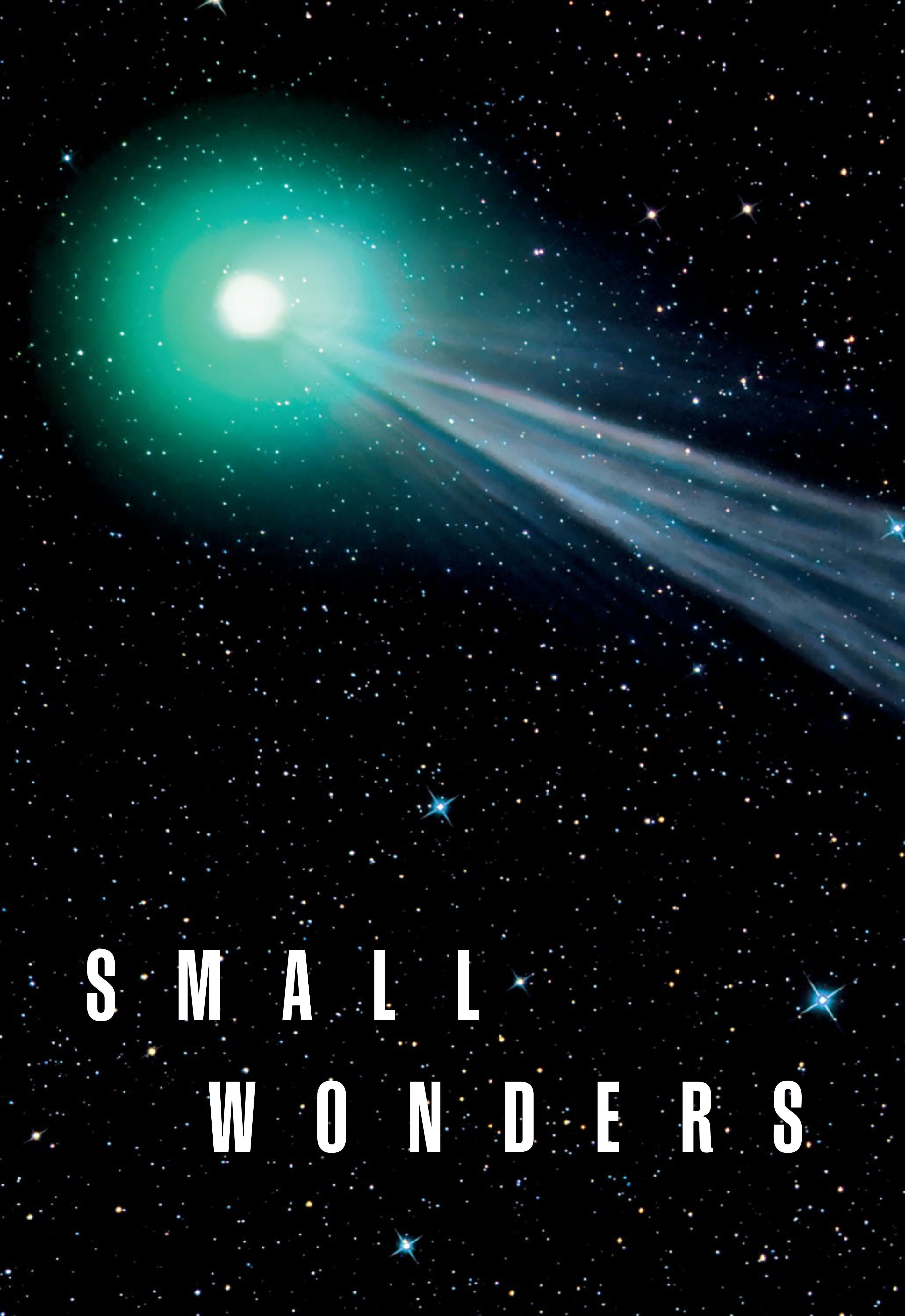
# FEATURES

60 ‘THE APPEAL OF CHEETAHS IS NO MYSTERY. AS CUBS, THEY HAVE HUGE ROUND EYES, FUZZY LITTLE BODIES, AND MOHAWK-LIKE RIDGES OF FUR DOWN THEIR BACKS.’

PHOTO: NICHOLE SOBECKI



# SMALL WONDERS

Modern astronomy is giving us unprecedented views of the tiny objects littering our solar system. These small bodies are yielding clues to the UNIVERSE'S BIGGEST MYSTERIES.

BY MICHAEL GRESHKO

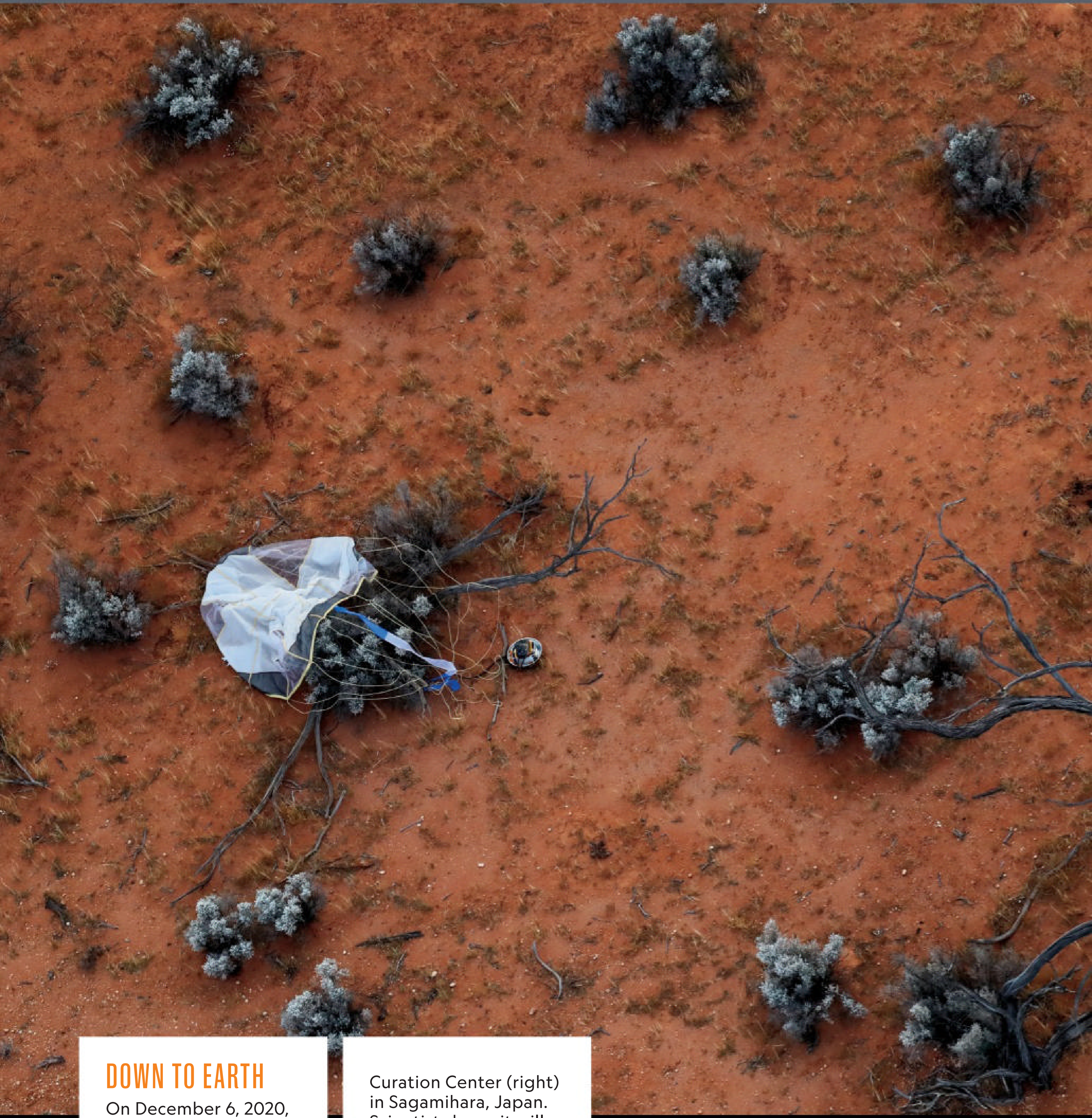
In 2015 comet C/2014 Q2 Lovejoy—seen here in a two-photo mosaic—neared the sun for the first time in millennia. Lovejoy likely hails from the Oort cloud, a distant shell of icy objects thought to surround the solar system. It's one of the roughly 4,000 known comets among the billions estimated to exist in our cosmic backyard.

## RUNNING ON SUN

A solar array for NASA's Lucy spacecraft unfurls as it is tested at a Lockheed Martin facility in Colorado. Set to launch in October, Lucy will need two of these arrays to generate power during its 12-year mission to explore Jupiter's Trojan asteroids. These ancient swarms, which orbit the sun alongside the giant planet, may hold clues to the solar system's original layout.

PATRICK H. CORKERY, LOCKHEED MARTIN

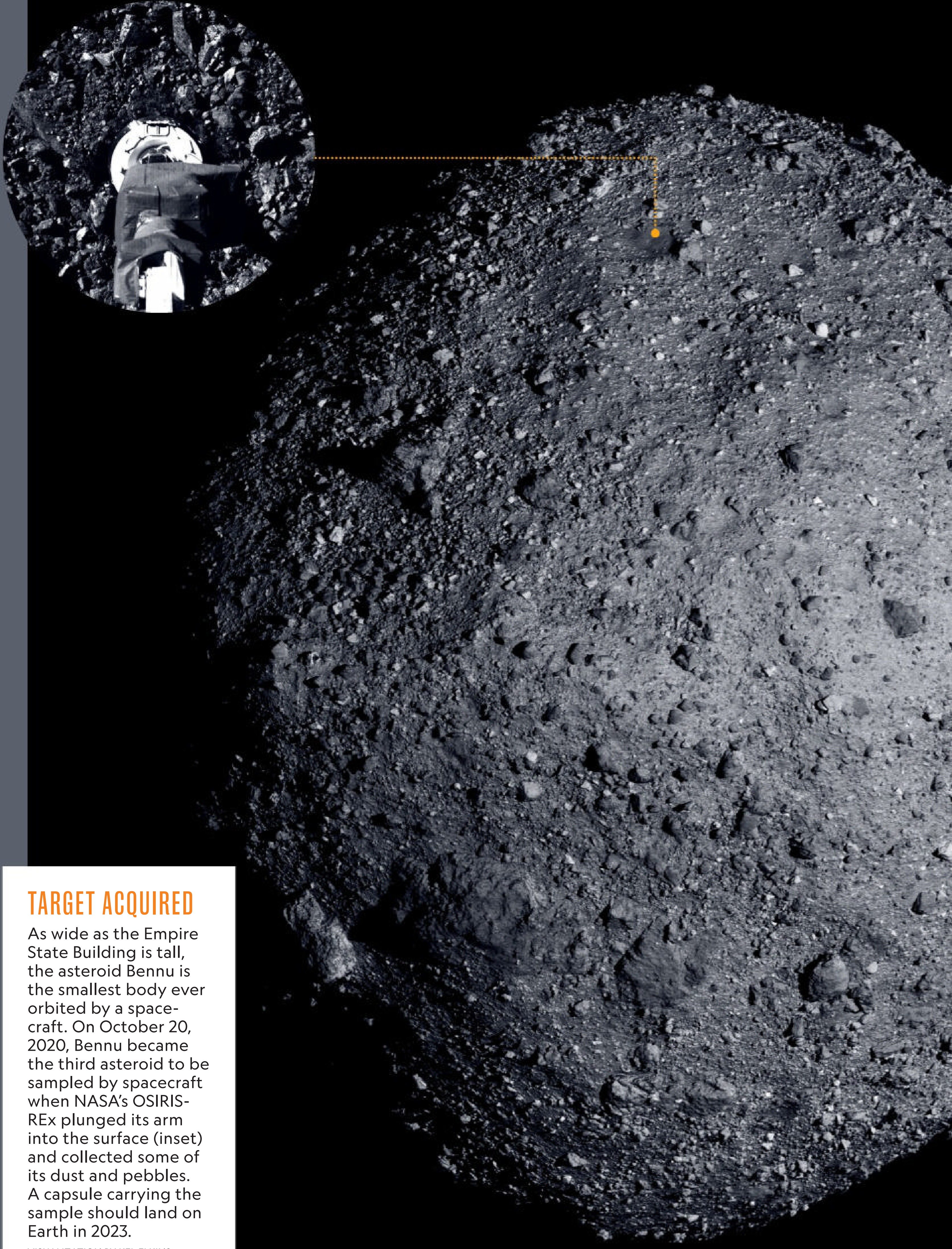
OPENING IMAGE: VELIMIR POPOV AND EMIL IVANOV AT THE IRIDA OBSERVATORY



## DOWN TO EARTH

On December 6, 2020, a capsule released by the Japanese spacecraft Hayabusa2 landed among the silvery saltbushes and terra-cotta soil of the Australian outback. The container held debris the spacecraft had collected from the near-Earth asteroid Ryugu in 2019. The ancient material now resides at the Extraterrestrial Sample Curation Center (right) in Sagamihara, Japan. Scientists hope it will help unlock secrets about early planet formation and perhaps even the origins of life on Earth. Although Hayabusa2's cargo has returned, the spacecraft is now on an extended mission that will take it to another asteroid in 2031.

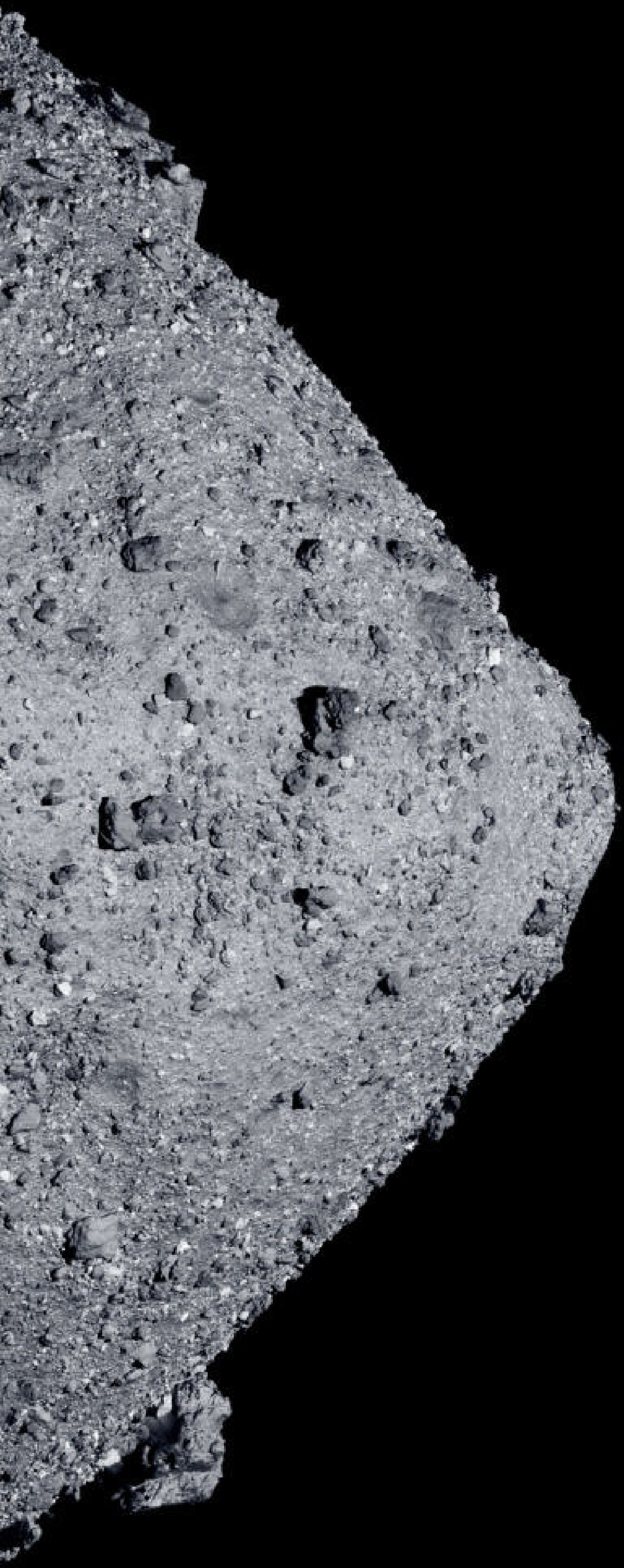
JAPAN AEROSPACE EXPLORATION AGENCY (LEFT); NORIKO HAYASHI (RIGHT)



**TARGET ACQUIRED**

As wide as the Empire State Building is tall, the asteroid Bennu is the smallest body ever orbited by a spacecraft. On October 20, 2020, Bennu became the third asteroid to be sampled by spacecraft when NASA's OSIRIS-REx plunged its arm into the surface (inset) and collected some of its dust and pebbles. A capsule carrying the sample should land on Earth in 2023.

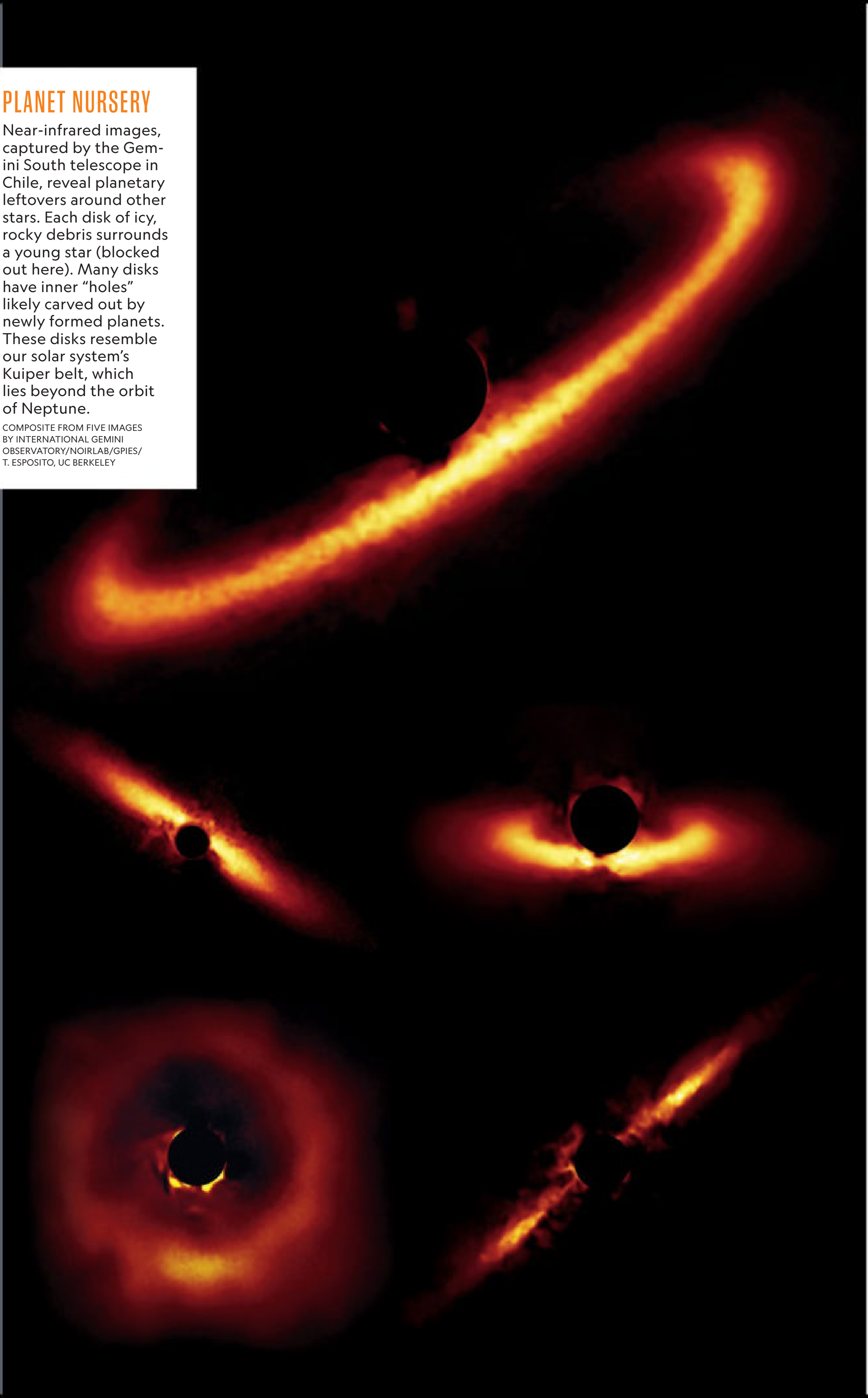
VISUALIZATION BY KEL ELKINS, NASA GODDARD SPACE FLIGHT CENTER; NASA GODDARD SPACE FLIGHT CENTER/UNIVERSITY OF ARIZONA (INSET)



# DANTE LAURETTA IS SERENE AS HE PREPARES FOR THE 17 SECONDS HE'S WORKED TOWARD FOR THE PAST 16 YEARS.

Lauretta, a University of Arizona planetary scientist, is transfixed by a monitor showing three simulated views of a rubbly, top-shaped object floating in a sea of stars. That's the asteroid known as 101955 Bennu. He's watching it while perched on an upholstered metal stool inside an unassuming building in Littleton, Colorado. With its cinder-block hallways, pop-out ceiling panels, and the occasional wasp problem, the building could be mistaken for a run-of-the-mill office suite. But the spacecraft decals on the walls and the labels above each cubicle—Electrical Power; Telecom; Guidance, Navigation & Control—reveal its true function: mission control at Lockheed Martin Space.

It's 1:49 p.m. mountain time on October 20, 2020, and the screen shows Bennu sitting within a green hoop that represents the orbit of a NASA spacecraft with a mouthful of a name: the Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer—OSIRIS-REx for short. In less than three hours, this robotic emissary will attempt to descend and touch Bennu for the first time, hopefully trapping a sample of extraterrestrial dust and pebbles for return to Earth.



### PLANET NURSERY

Near-infrared images, captured by the Gemini South telescope in Chile, reveal planetary leftovers around other stars. Each disk of icy, rocky debris surrounds a young star (blocked out here). Many disks have inner "holes" likely carved out by newly formed planets. These disks resemble our solar system's Kuiper belt, which lies beyond the orbit of Neptune.

COMPOSITE FROM FIVE IMAGES BY INTERNATIONAL GEMINI OBSERVATORY/NOIRLAB/GPIES/ T. ESPOSITO, UC BERKELEY

Launched in 2016, OSIRIS-REx h
the sun twice to catch up with Benn
more than 200 million miles away on
October day. At roughly a third of a
Bennu is the smallest celestial body a
has ever orbited. Its surface is so rugg
ta's team spent a year mapping it to
place to descend. All this buildup sh
today's main event a tense moment,
late stage of the billion-dollar missio
seems at peace.

"The spacecraft is in a really g
today," he tells me.

Why go through all this stress an
a few pounds of dust and rubble? F
the asteroid's building blocks form
the solar system's earliest days, mo
billion years ago. These rocks, which
they contain carbon, represent a prist
of how the planets formed and perh
Earth got the starter materials for life
ically, it's literally pay dirt," Lauretta

But just as Bennu carries the stuff of
also has the power to destroy. Bennu c
enough to Earth that astronomers beli
a small but serious chance—one in 2,7
could collide with us between 2175 an
samples OSIRIS-REx brings back coul
designing the right defense against
that could release more than two mi
the energy of the ammonium nitrat
rocked Beirut a year ago—enough to
a state or province, possibly even a c

On a grander scale, Bennu and O
symbolize two parallel revolutions
astronomy that are upending old con
the solar system. Today's telescopes ca
small, faint objects than ever befor
astronomers to survey the skies and
cosmic population that surrounds the
ets. Twenty years ago, humans knew
a hundred thousand celestial bodies
system. By early 2021, we'd catalog
more than a million objects orbiting

At the same time, space agencies a
world have developed the tools and te
to visit and explore these worlds—and
pieces of them back to Earth for clos

The stakes are far from abstract.

The picture of the solar system we
in school seems to have a logical ar
But astronomers and planetary scie
suspected for decades that something

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ntists have
was amiss,

since by the looks of it, it's extremely difficult to explain how Uranus and Neptune could have formed where they orbit today. Our cosmic home appears to be missing some of the most common types of planets that orbit alien stars. And as of 2021, Earth is the only known harbor for life.

So how, exactly, did our solar system end up here—and give rise to its inhabitants?

Small bodies such as Bennu were long dismissed as mere leftovers in the process that created the planets. But now researchers know how important these bodies are in the search to answer such massive questions. Like Bennu, many are time capsules, essentially unchanged since the birth of our sun. Others could similarly pose a threat to life on Earth. By tracking, visiting, and sampling these primordial worlds, we're finally getting a chance to see where we came from—and to hopefully stop these objects from destroying who we've become.

**HUMANKIND'S INTEREST** in small bodies—astronomer-speak for every natural object orbiting the sun that isn't a planet, dwarf planet, or moon—has been with us as long as there have been people looking up. For millennia, cultures around the world have spotted the comets and meteors visible in the night sky and treated them as important omens. There was only so much people could do to learn more, though, because small bodies reflect very little sunlight and therefore are hard to find in the blackness of space.

By the dawn of the 20th century, astronomers had found roughly 500 asteroids orbiting the sun, starting with the 1801 discovery of Ceres. The pace of discovery really began to crank up in the 1980s and '90s as telescopes improved. In 1992 astronomers spotted the first world—aside from Pluto and one of its moons—that is beyond Neptune's orbit, confirming theories of the solar system's outer zone now called the Kuiper belt. Today astronomers know this far-flung region is filled with thousands—perhaps hundreds of thousands—of icy bodies.

But if you had to pinpoint when the small-body frenzy began, a reasonable choice would be March 11, 1998. That's when the U.S.-based Minor Planet Center, the world's official repository of all asteroid and comet orbits, issued an ominous-sounding press release: An asteroid

# DUSTY BEGINNINGS

In the wake of our sun's formation, a cloud of dust and gas was left swirling around the infant star. Gradually these materials began to clump together, forming the beginnings of planets. In the celestial chaos, these objects collided, sometimes forming larger bodies and other times being broken up entirely. Over four billion years later, countless bits of leftover rubble remain trapped in the gravity of our sun and its planets.

# MULTITUDES OF MINORS

Leftover fragments of planetary building blocks orbit the sun in the form of asteroids, comets, and dwarf planets. Ranging from pristine to geologically active, these small bodies offer clues to our solar system's history through their composition, orbit, and behavior.

## Rocky residuals

**Objects that orbit closer to the sun are mostly small and rocky. Jupiter's gravity likely prevented the formation of a planet in the main asteroid belt and caused early protoplanets to collide and break apart. Their combined mass is less than that of Earth's moon.**

Some ejected particles are retained by gravity.

Rotation is speeding up, which could alter its orbit.

Diameter: 1,850 ft

Meteorites from Vesta

### BENNU: CLINGING SHARDS

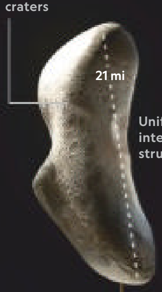
This spinning collection of gravity-bound rubble shows its age with dark, cracked surface rocks that have been weathered by the sun.

*BENNU,*
**OSIRIS-REx, 2018-2021**

Mission name,* date visited

### EROS: BRIGHT AND STONY

Eros is one of thousands of asteroids that cross Earth's orbit and may be fragments from larger asteroids or the burned-out remnants of comets.



Deep dust ponds in craters

21 mi

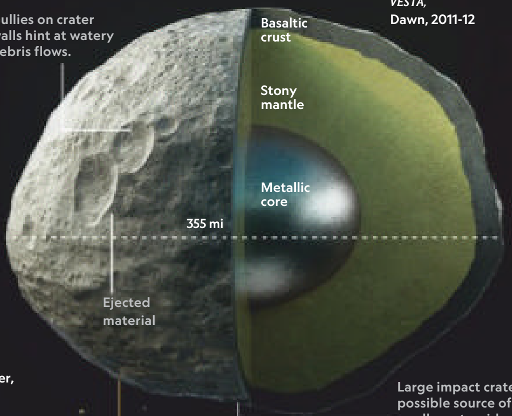
Uniform internal structure

*EROS,*
**NEAR Shoemaker, 1998-2001**

### VESTA: INTACT PROTOPLANET

Models suggest that as many as a hundred emerging planets started to form. Vesta, the largest asteroid, appears to be the only intact survivor. Craters, fractures, and lava flows scar this object's surface.

*VESTA,*
**Dawn, 2011-12**



Gullies on crater walls hint at watery debris flows.

Basaltic crust

Stony mantle

Metallic core

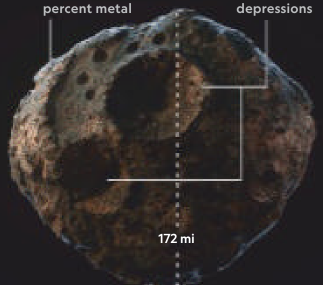
355 mi

Ejected material

Large impact crater; possible source of smaller asteroids

### PSYCHE: RARE ORB

Did collisions rip off a rocky layer surrounding the metallic core of an ancient developing planet? An upcoming mission will investigate whether that's Psyche's origin story.



Thought to be up to 60 percent metal

At least two large depressions

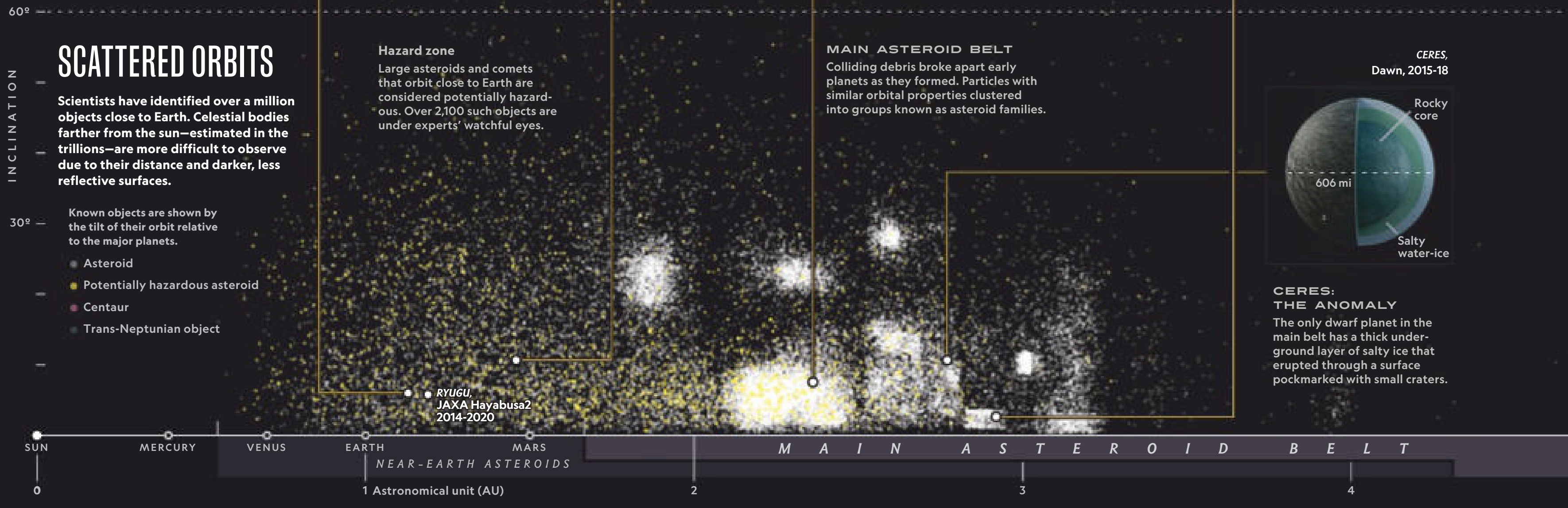
172 mi

*Artist's interpretation*

*PSYCHE,*
**Psyche, launch 2022**

## SCATTERED ORBITS

**Scientists have identified over a million objects close to Earth. Celestial bodies farther from the sun—estimated in the trillions—are more difficult to observe due to their distance and darker, less reflective surfaces.**



Known objects are shown by the tilt of their orbit relative to the major planets.

- ● Asteroid
- ● Potentially hazardous asteroid
- ● Centaur
- ● Trans-Neptunian object

**Hazard zone**

Large asteroids and comets that orbit close to Earth are considered potentially hazardous. Over 2,100 such objects are under experts' watchful eyes.

*RYUGU,*
**JAXA Hayabusa2 2014-2020**

### MAIN ASTEROID BELT

Colliding debris broke apart early planets as they formed. Particles with similar orbital properties clustered into groups known as asteroid families.

*CERES,*
**Dawn, 2015-18**

### CERES: THE ANOMALY

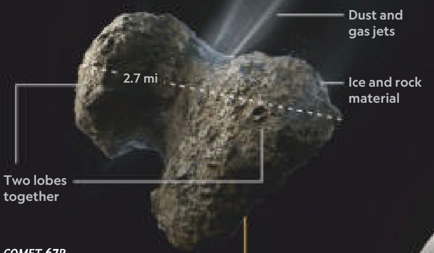
The only dwarf planet in the main belt has a thick underground layer of salty ice that erupted through a surface pockmarked with small craters.

BODIES NOT TO SCALE. *NASA MISSION UNLESS OTHERWISE IDENTIFIED. †OBJECT COUNT AS OF JUNE 30, 2021.

# Beyond the frost line

At this distance from the sun, water begins to condense into ice. Bodies typically are icier and gassier, with more elliptical orbits. Out here many objects are paired, both small and planet-size.

**1,099,978** BODIES HAVE BEEN CATALOGED IN OUR SOLAR SYSTEM. TRILLIONS HAVE YET TO BE IDENTIFIED.†



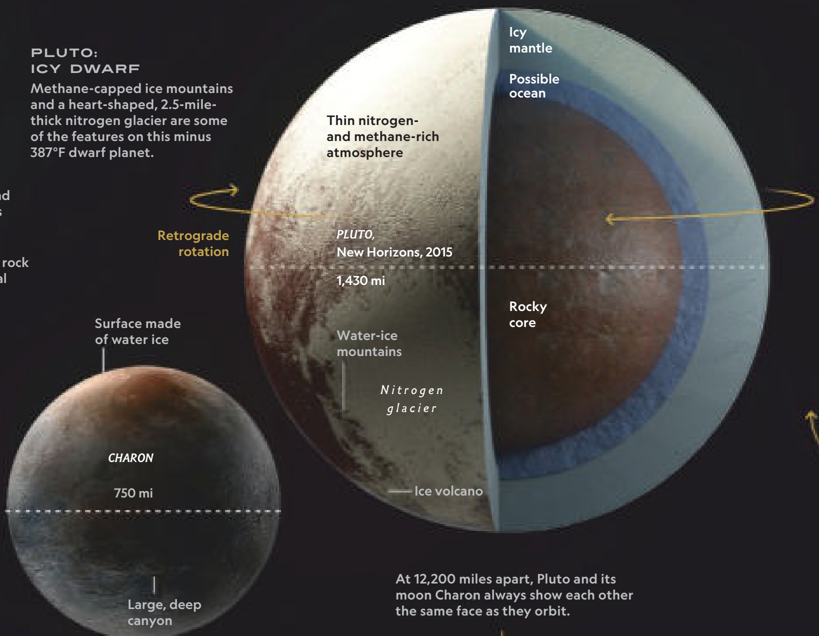
*COMET 67P CHURYUMOV-GERASIMENKO,*
ESA Rosetta, 2014-16

## COMET: ICY CONTACT

Porous, pitted, and spewing dust-filled water vapor, comets also have been shown to sometimes host life-building compounds.

## PLUTO: ICY DWARF

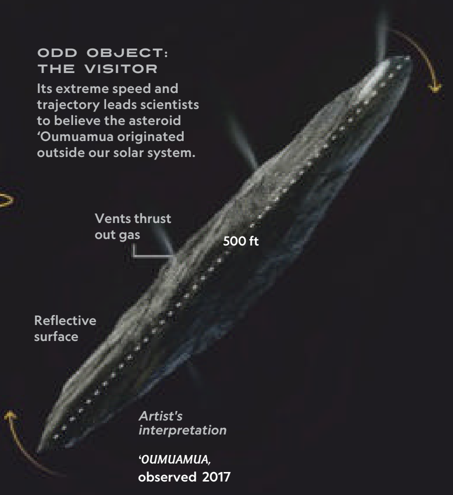
Methane-capped ice mountains and a heart-shaped, 2.5-mile-thick nitrogen glacier are some of the features on this minus 387°F dwarf planet.



At 12,200 miles apart, Pluto and its moon Charon always show each other the same face as they orbit.

## ODD OBJECT: THE VISITOR

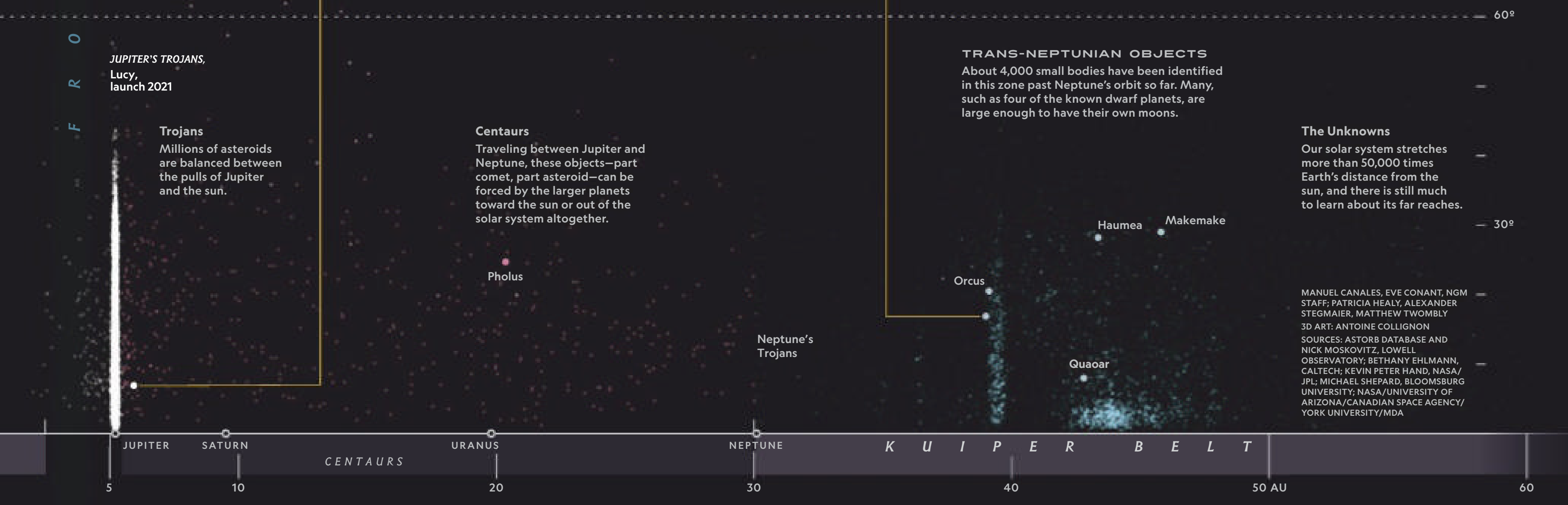
Its extreme speed and trajectory leads scientists to believe the asteroid ʻOumuamua originated outside our solar system.



*ʻOUMUAMUA,*
observed 2017

**How we know**

Sometimes when objects pass in front of a brighter body, information about their size and shape can be revealed.



*JUPITER'S TROJANS,*
Lucy,
launch 2021

**Trojans**

Millions of asteroids are balanced between the pulls of Jupiter and the sun.

**Centaurs**

Traveling between Jupiter and Neptune, these objects—part comet, part asteroid—can be forced by the larger planets toward the sun or out of the solar system altogether.

## TRANS-NEPTUNIAN OBJECTS

About 4,000 small bodies have been identified in this zone past Neptune's orbit so far. Many, such as four of the known dwarf planets, are large enough to have their own moons.

**The Unknowns**

Our solar system stretches more than 50,000 times Earth's distance from the sun, and there is still much to learn about its far reaches.

MANUEL CANALES, EVE CONANT, NGM STAFF; PATRICIA HEALY, ALEXANDER STEGMAIER, MATTHEW TWOMBLY
3D ART: ANTOINE COLLIGNON
SOURCES: ASTORB DATABASE AND NICK MOSKOVITZ, LOWELL OBSERVATORY; BETHANY EHLMANN, CALTECH; KEVIN PETER HAND, NASA/JPL; MICHAEL SHEPARD, BLOOMSBURG UNIVERSITY; NASA/UNIVERSITY OF ARIZONA/CANADIAN SPACE AGENCY/YORK UNIVERSITY/MDA

MANUEL CANALES, NGM STAFF; PATRICIA HEALY, ALEXANDER STEGMAIER
ART: ANTOINE COLLIGNON
SOURCES: KEVIN PETER HAND, NASA/JPL; NICK MOSKOVITZ, LOWELL OBSERVATORY; MICHAEL SHEPARD, BLOOMSBURG UNIVERSITY

discovered the previous December would come within 26,000 miles of Earth's surface in 2028, with a small chance it would hit the planet.

The story quickly made headlines around the world, and the news hit a public increasingly aware of how much damage an asteroid could deal. A few years earlier, geologists had identified the crater left by the asteroid that struck Earth 66 million years ago, killing off all the dinosaurs except birds. Was the incoming space rock the next Big One?

Astronomers raced to double-check their calculations. By the next day, Don Yeomans and Paul Chodas with NASA's Jet Propulsion Laboratory had figured out that the asteroid would sail harmlessly by Earth at a distance of 600,000 miles. Whew—crisis averted. Still, the back-and-forth cast a glaring spotlight on how little support there had been for finding killer asteroids.

By coincidence, the Hollywood blockbusters *Deep Impact* and *Armageddon* premiered just months after the affair, reinforcing asteroid impacts as the apocalypse du jour. In May 1998 Congress told NASA to find at least 90 percent of all asteroids at least six-tenths of a mile wide that come within 121 million miles of the sun, and to do it within a decade. By July NASA had designated an office to oversee the asteroid search.

Astronomers didn't just have political will on their side. They also had the right technology. By the late 1990s digital camera sensors had gotten big and sensitive enough to outperform the cumbersome glass plates used for decades to take pictures of the night sky. Telescopes suddenly could see smaller, fainter, and more distant objects. And because the new data arrived digitized, researchers could analyze them with computer software, simplifying the process.

Mike Brown, an astronomer at California Institute of Technology in Pasadena, saw firsthand what followed. In 2002 Brown and his colleagues decided to upgrade the 48-inch-wide telescope at California's Palomar Observatory with a large digital camera. When Brown aimed the instrument toward the Kuiper belt in hope of finding objects bigger and brighter than the region's few hundred known denizens, his team started discovering so many new worlds, "I just felt like things were falling out of the sky," he says.

Brown's discoveries included three objects that each were at least half as wide as Pluto, and one—named Eris for the Greek goddess of discord—that was more massive. So in 2006 the

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presence of an unseen planet several
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bout what all these strange objects
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the evolution of the solar system. To
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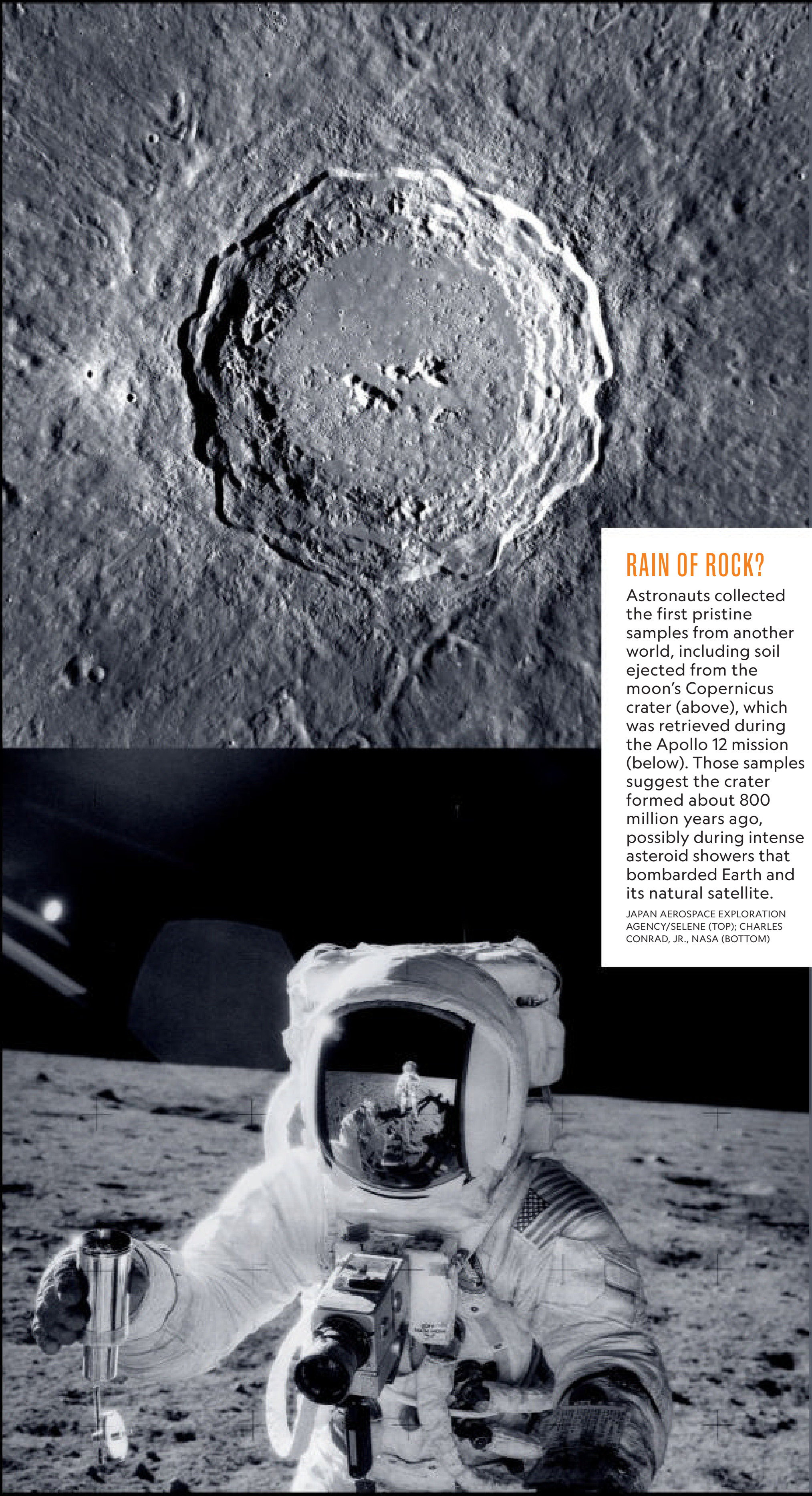


## RAIN OF ROCK?

Astronauts collected the first pristine samples from another world, including soil ejected from the moon's Copernicus crater (above), which was retrieved during the Apollo 12 mission (below). Those samples suggest the crater formed about 800 million years ago, possibly during intense asteroid showers that bombarded Earth and its natural satellite.

JAPAN AEROSPACE EXPLORATION AGENCY/SELENE (TOP); CHARLES CONRAD, JR., NASA (BOTTOM) asteroid. The Hayabusa mission rendezvoused with the asteroid 25143 Itokawa in 2005, but the sampling maneuver didn't go as planned. A capsule bearing only a light sprinkling of its dust grains landed in Woomera in 2010. Its successor, Hayabusa2, set off in 2014 to the near-Earth asteroid 162173 Ryugu—and did its best impression of a superhero's bottomless utility belt once it arrived at its target.

Inside the spacecraft, engineers had packed a suite of scientific instruments, a lander, three rovers, an impactor designed to make an artificial crater, and a breakaway camera that filmed the blast while the main spacecraft moved out of range for its own safety. Those accessories aided Hayabusa2 in its ultimate goal: twice alighting on Ryugu, firing a pellet into its surface, and collecting the schmutz that sprayed outward.

Now, 5.4 grams of jarringly dark grains and pebbles are in a lab outside Tokyo, shepherded there from the Australian outback by Tachibana's team. This is humankind's first up-close look at Ryugu's surface and subsurface, and upcoming studies will provide invaluable records of the solar system's history.

Until missions such as Hayabusa2, scientists relied on meteorites that had fallen to Earth to delve into the solar system's origins. Some of these primordial lumps indicated that the asteroids that shed them contain a surprising amount of water-bearing minerals, as well as the types of carbonaceous chemistry that can give rise to some of life's building blocks. But even these extraordinary insights come with a catch: Meteorites aren't completely pristine, having gotten to Earth's surface only after surviving a fiery descent through our atmosphere.

By visiting asteroids in space and sampling them, scientists may help solve an enduring mystery: How did Earth's surface become an oasis for life, even though the planet formed so close to the sun? As it took shape more than 4.5 billion years ago, our home world went through a scorching, hellish youth. Yet here we sit, our pale blue dot sloshing through space as a biological haven that depends on water and carbon.

Some research suggests that despite baking in the inner solar system, the infant Earth's building blocks could have contained enough hydrogen to account for much of our planet's water. But meteorites and impact craters across the solar system point to another, paradoxically violent source of hydration: bombardment by asteroids and comets. So far, missions sent out to small bodies have provided tantalizing hints of these ancient impacts' boosts to Earth's prebiotic chemistry.

BY VISITING ASTEROIDS, SCIENTISTS HOPE TO LEARN HOW EARTH'S SURFACE BECAME AN OASIS FOR LIFE, EVEN THOUGH THE PLANET FORMED SO CLOSE TO THE SUN.

The 1,500 grains of Itokawa returned by the first Hayabusa mission show that the asteroid's minerals contain water that looks chemically similar to Earth's. And when the European Space Agency's Rosetta mission became the first spacecraft to orbit and land a probe on a comet, between 2014 and 2016, it revealed that up to a quarter of the comet's mass is made up of organic molecules formed by nonliving processes. It also showed that some of the material brought to an infant Earth may have been especially fragrant: Based on its chemical profile, the comet would smell like a noxious blend of rotten eggs, formaldehyde, and a horse stable's harsh fumes, with a dash of almond.

Clearly, small bodies aren't bit players in the epic saga of Earth's evolution—they're central characters. But we can't just think in terms of their utility to Earth. If anything, robotic missions have underscored that asteroids and comets are tiny worlds with terrains all their own. These objects cover such a wide range of shapes, sizes, and histories, "it's as if we suddenly have a million new kinds of worlds to explore," says Arizona State University planetary scientist Lindy Elkins-Tanton, who is principal investigator on a NASA mission to explore an oddly reflective, likely metallic asteroid called Psyche.

Beyond their makeup, the diverse movements of small bodies are revealing how important these worlds have been in shaping the star system we all call home.

**THE SAME COLORADO BUILDING** that houses OSIRIS-REx's mission control contains the cavernous room where engineers build other NASA missions—including a robotic paleontologist of sorts that soon will trek toward Jupiter. To see this spacecraft back in October, I put on my space-day best—a face mask and a slippery, head-to-toe "bunny suit" designed to prevent my clothes and skin from contaminating anything. Then I walk into a huge, cream-colored clean room humming with ventilation. Hal Levison and Cathy Olkin, scientists at the Southwest Research Institute in Boulder, join me.

Levison and Olkin are the principal and deputy principal investigators, respectively, on the first mission to explore Jupiter's Trojan asteroids, two swarms of primordial objects that lead and follow Jupiter in its orbit around the sun. The way Olkin and Levison see it, the Trojans are the solar system's fossils, so Olkin suggested they name the mission Lucy, in honor of the famous skeleton of *Australopithecus afarensis,* a distant ancestral cousin of *Homo sapiens*.

It's not just my first up-close look at this spacecraft; it's Levison's too. As it happens, the engineers building Lucy are testing a key mechanism while we're visiting. To keep the spacecraft's gaze fixed on its targets during a planned series of high-speed flybys, Lucy's instruments sit on a platform that, in turn, is mounted to the spacecraft's chassis via a dual-axis gimbal, not unlike the one that stabilizes handheld cameras. The entire mission rests on that one robotic limb. If it flexes incorrectly or at the wrong time, Lucy's instruments may collect blurred data—or at worst, stare into darkness.

We form a spaced arc around the rig, eager for the show. It moves slowly, methodically, and even this small motion delights Olkin and Levison. "It's alive! It's alive!" Levison jokingly exclaims. The pair's eyes stay glued to their team's creation as it stirs awake.

The Jupiter Trojans that Lucy will study present a dynamical riddle: They don't appear to have formed in place, but their orbits are extremely hard to enter because they are so similar to the giant planet's path around the sun. If today's small bodies were to try and invade Jupiter's turf like this, they'd most likely collide with the behemoth or get scattered by its gravity, possibly even getting kicked out of the solar system. So how did Jupiter acquire its entourage?

In 2005 Levison and his colleagues at the Côte d'Azur Observatory in Nice, France, published an influential hypothesis, now called the Nice model, which posits that the solar system began with many more small bodies than it has now, and that Jupiter, Saturn, Uranus, and Neptune formed closer to the sun than they currently orbit. As small bodies gravitationally tugged at the gas giants, the planets' orbits shifted until they slipped into an unstable configuration.

Suddenly, the planets are thought to have reeled and staggered, their orbits ballooning outward to their current positions, where Jupiter captured its Trojans. In the fray, many small bodies either scattered inward toward the sun or got ejected from the solar system. The inner planets, including Earth, may have felt the aftereffects as an increase in bombardments. "The solar system is really like somebody picked it up early on and shook it real hard," Levison says.

After launching this October, Lucy will fly by a series of target Trojans from 2027 to 2033. The bodies' color, composition, density, and cratering should help researchers figure out when and where each formed within the solar system, aiding similar estimates for the rest of the Jupiter Trojans. These data will throw down a gauntlet: To have a shot at being correct, future simulations of early solar system formation must replicate whatever patterns Lucy finds. Along the way, the spacecraft will snap the first resolved images of the Trojans humans have ever seen.

"This is the last stable population of minor planets that hasn't been explored," Olkin says. "The time is right."

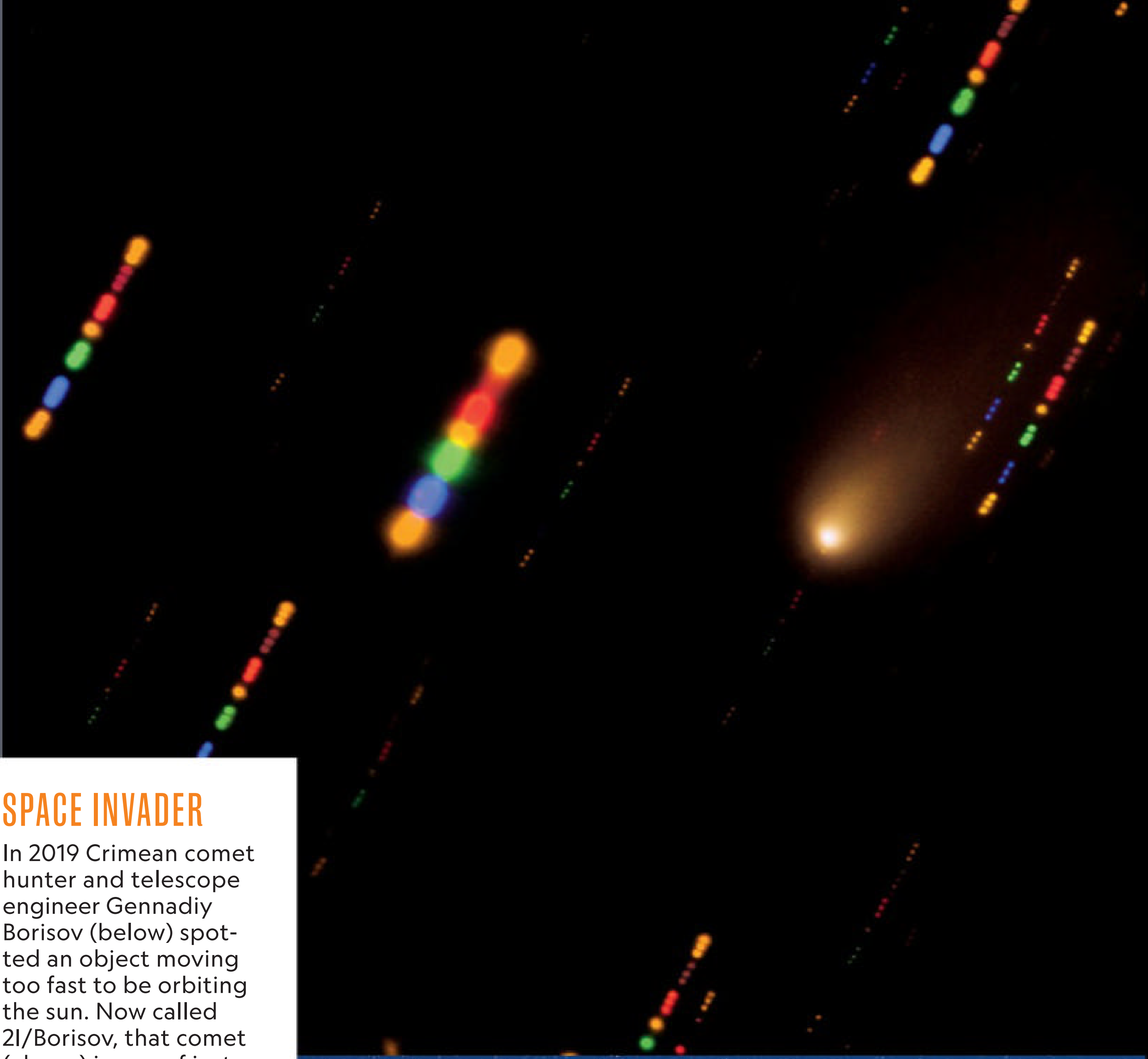
**DESPITE ALL THIS PROGRESS,** astronomers know we're only beginning to scratch the surface of what's out there—and what perks or perils might be lurking in the darkness.

When the Vera C. Rubin Observatory begins operations in 2023 in Chile, it will spend a decade mapping the southern night sky in stunning detail, most of it 825 times over. University of

**EYE ON THE SKY**

Engineers huddle beneath the two-foot-wide sensor array that will power the Vera C. Rubin Observatory's 3.2-gigapixel digital camera, the biggest ever built for astronomy. Under construction in Chile, the U.S.-funded observatory is expected to find about five million more asteroids, comets, and other small bodies after it goes online in 2023.

JACQUELINE ORRELL, SLAC NATIONAL ACCELERATOR LABORATORY



## SPACE INVADER

In 2019 Crimean comet hunter and telescope engineer Gennadiy Borisov (below) spotted an object moving too fast to be orbiting the sun. Now called 2I/Borisov, that comet (above) is one of just two large bodies from other stars we've seen moving through the solar system. Thousands of interstellar interlopers are likely out there right now.

O. HAINAUT, EUROPEAN SOUTHERN OBSERVATORY (TOP); YULIA ZHULIKOVA (BOTTOM)

Washington astronomer Željko Ivezić, the survey's project scientist, often likens the survey to filming "the greatest movie of all time." Stitch all of its pictures together into a cosmic time lapse, and the resulting video could run in full-color HD for 11 months straight.

By the end of 2033, the Rubin Observatory is expected to dramatically increase the count of known small bodies. Its predicted haul includes another five million asteroids in the main belt, about 300,000 Jupiter Trojans, 40,000 objects beyond Neptune—and 10 to a hundred objects passing through our solar system that formed around alien stars, adding to the two astronomers have found since 2017.

For Michele Bannister, an astronomer at New Zealand's University of Canterbury, the Rubin Observatory's potential discoveries evoke awe. "We basically have been the kids on the seashore, standing there picking up a few shells and admiring how beautiful they are," she says, "and all around us is this vast ocean spreading out—which is suddenly going to be something we can go out and explore."

Mapping this celestial sea also is expected to find another 100,000 near-Earth asteroids that come within 121 million miles of the sun, some of which may be "potentially hazardous" like Bennu: objects wider than 500 feet, with orbits that take them within 4.7 million miles of Earth's path around the sun. If we've learned anything from COVID-19, let alone the climate and extinction crises, it's that the systems that undergird modern civilization are brittle. Now imagine throwing a big space rock at them.

"Obviously, near-Earth asteroids and comets, that's a much less likely problem compared to something like this pandemic," says Amy Mainzer, a University of Arizona planetary scientist who specializes in near-Earth asteroids. "But ... eventually, if you wait long enough, the unlikely events—they will happen."

Protecting Earth from such a fate won't require ragtag crews of nuke-toting astronauts, like in the movies. If astronomers can forecast a collision with enough notice, a zippy spacecraft could be launched in time to hit the asteroid and render its orbit harmless. In 2022 a NASA mission built and managed by the Johns Hopkins University Applied Physics Laboratory will try out this maneuver with a spacecraft called the Double Asteroid Redirection Test, or DART for short. DART will slam into a near-Earth asteroid's tiny moonlet at about 15,000 miles an hour, shortening the moonlet's orbit by as much as 10 minutes.

If DART proves a success, future humans may need to use a scaled-up version of this maneuver to keep Bennu in check. But first, much smaller pieces of Bennu will soar harmlessly through our atmosphere—thanks to that spacecraft being commanded from the Denver suburbs.

IT'S NOW 4:13 P.M. MOUNTAIN TIME on October 20, 2020, and the 17 seconds Dante Lauretta long awaited have come and gone—to his utter delight.

Two minutes earlier, he and his team received word that OSIRIS-REx was within five meters of Bennu's surface, and that the spacecraft's onboard hazard-detection system had given it the green light to proceed. Wearing a clear plastic mask to show more of his face under COVID-19 protocols, Lauretta breaks into a smile. Asked how he feels, he comes up with just one word: "Transcendental."

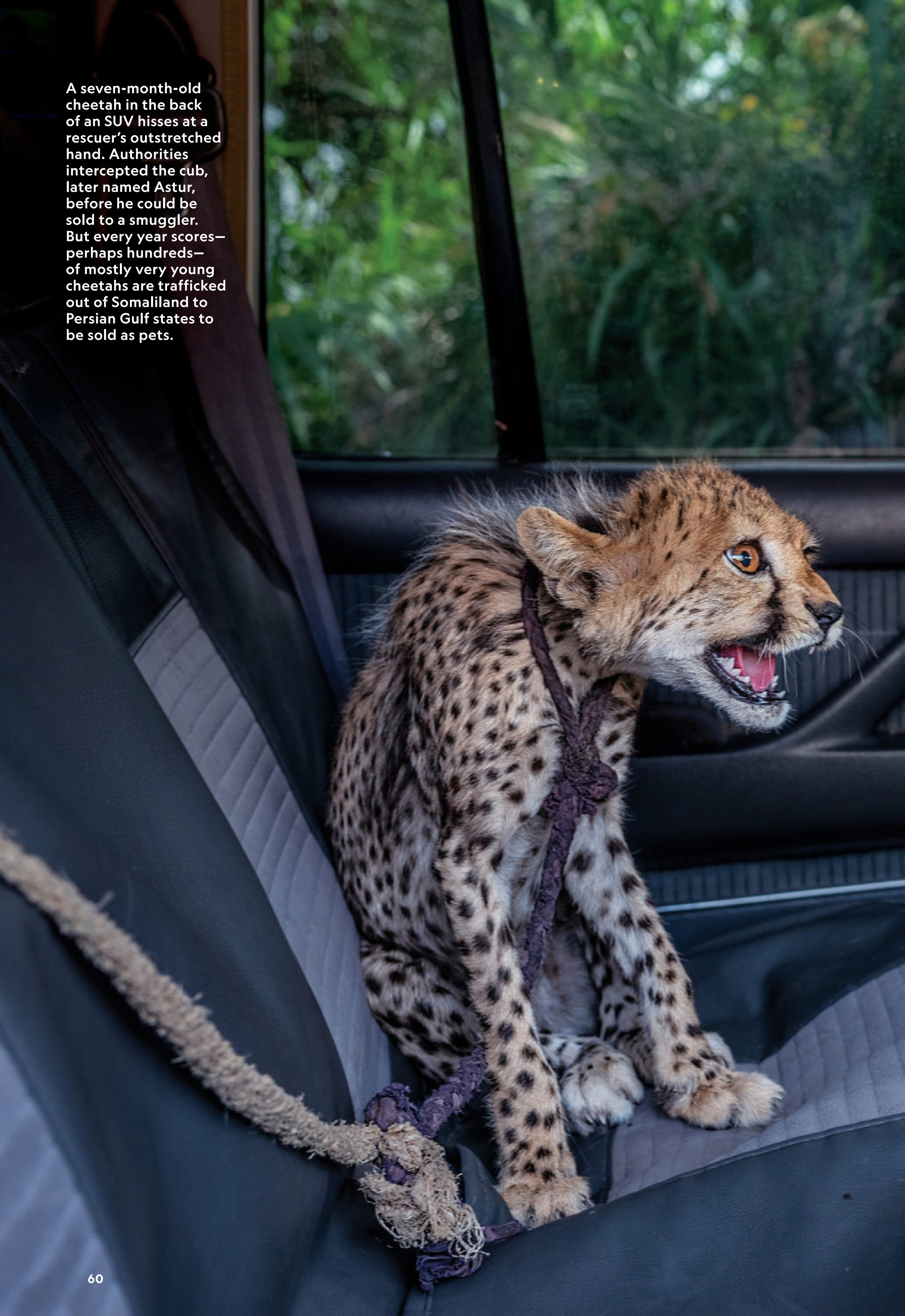
Systems engineer Estelle Church then confirms that the commands she sent have been executed. Millions of miles from Earth, dodging boulders bigger than houses, OSIRIS-REx has collected its bounty and is backing away.

The tip of OSIRIS-REx's sampling arm got so packed with debris that it jammed open, and the team had to rush to seal the leaking container within its return capsule. As a result, they don't know how much of Bennu they'll be bringing back to Earth when OSIRIS-REx drops off the capsule in 2023. But they suspect it'll be plenty, and that a closer look at its chemistry will shake up our understanding of biological beginnings.

"The likelihood that there's life elsewhere in the galaxy, even in the universe—we're gonna understand that a lot better," Lauretta says.

We're made of star stuff, as the old Carl Sagan adage goes. But as products of the solar system, we also could see ourselves as Bennu brothers, Psyche sisters, comet cousins—kin to the asteroids and comets that chronicle our deepest histories. In a sense, we too are the sun's small bodies: endlessly diverse and beautiful, bearing the secrets of life itself. □

**Michael Greshko** is a staff science writer for *National Geographic*.



A seven-month-old cheetah in the back of an SUV hisses at a rescuer's outstretched hand. Authorities intercepted the cub, later named Astur, before he could be sold to a smuggler. But every year scores—perhaps hundreds—of mostly very young cheetahs are trafficked out of Somaliland to Persian Gulf states to be sold as pets.

# Cheetahs for Sale

The regal cat is coveted by traffickers who sell wild animals to wealthy buyers. This is how one criminal network has smuggled cubs out of Africa—and how Somaliland is fighting back.

BY **RACHAEL BALE**

PHOTOGRAPHS BY **NICHOLE SOBECKI**

FILLED MILK POWDER
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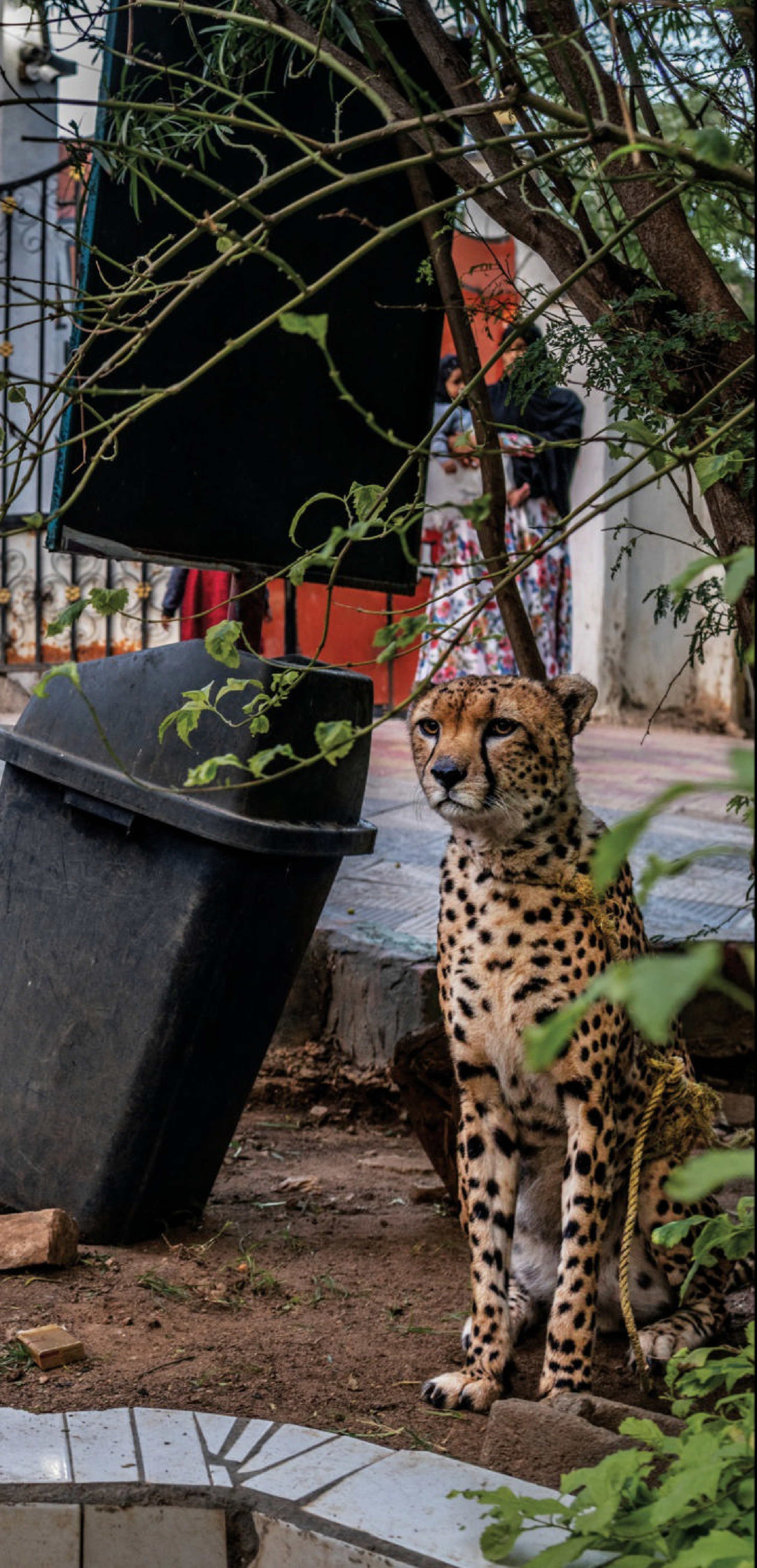


At the entrance to a popular restaurant in Hargeysa, Somaliland's capital, a cheetah sits on display near a trash can and rusty paint pail. Somaliland, not recognized as an independent nation by most countries, is striving to fight the illegal wildlife trade. Still, for many Somalilanders who are struggling to get by, protecting wildlife isn't a priority.

# Do you know these animals?

The question from the prosecutor is about the five cheetah cubs pressed together in a carrier, and held up for two defendants to see from their barred cell at the front of the courtroom. The cubs' birdlike chirps of distress echo off the concrete floor and walls.

One of the two, Cabdiraxmaan Yusuf Mahdi, better known as Cabdi Xayawaan, glances at the cubs. "I've never seen them before," he says with a wave of his hand.

A pause, then the second man, Maxamed Cali Guuleed, speaks: They look a little smaller, maybe, but those are the cubs from my house.

The men are on trial in Hargeysa, the capital of Somaliland, a self-declared autonomous republic in the Horn of Africa. They're accused of taking cheetah cubs from the wild at a time when Somaliland is cracking down on the networks that have made the region a hub for trafficking of the iconic, and increasingly rare, cats.

This case began in October 2020 when police, acting on a tip, launched an operation that led to the discovery of 10 cubs in Guuleed's home and to his and Cabdi Xayawaan's arrests. It was the sixth interception of cheetahs in four months in Somaliland.

With an airline eye mask and a tissue in his ears to help him stay sedated, Astur undergoes an intake exam at one of the nonprofit Cheetah Conservation Fund's (CCF) rescue centers in Hargeysa. Cubs smuggled or intercepted from criminal rings often get sick, typically because they're subjected to long, grueling journeys and deprived of proper nutrition. Many don't survive.

Guuleed approaches the cell's bars to address the judge. He says he'd been caring for the cubs as a favor to his new friend, Cabdi Xayawaan, whom he'd met a few months before. When Cabdi Xayawaan had asked Guuleed to store some property at his house temporarily, Guuleed had agreed.

That "property" turned out to be the cheetahs. Cabdi Xayawaan pulled up at Guuleed's house with the cubs in woven plastic sacks in the back of his silver SUV. He gave Guuleed a few hundred dollars to buy goat meat and milk for the animals, Guuleed says. He insists that he didn't know keeping the cubs was illegal.

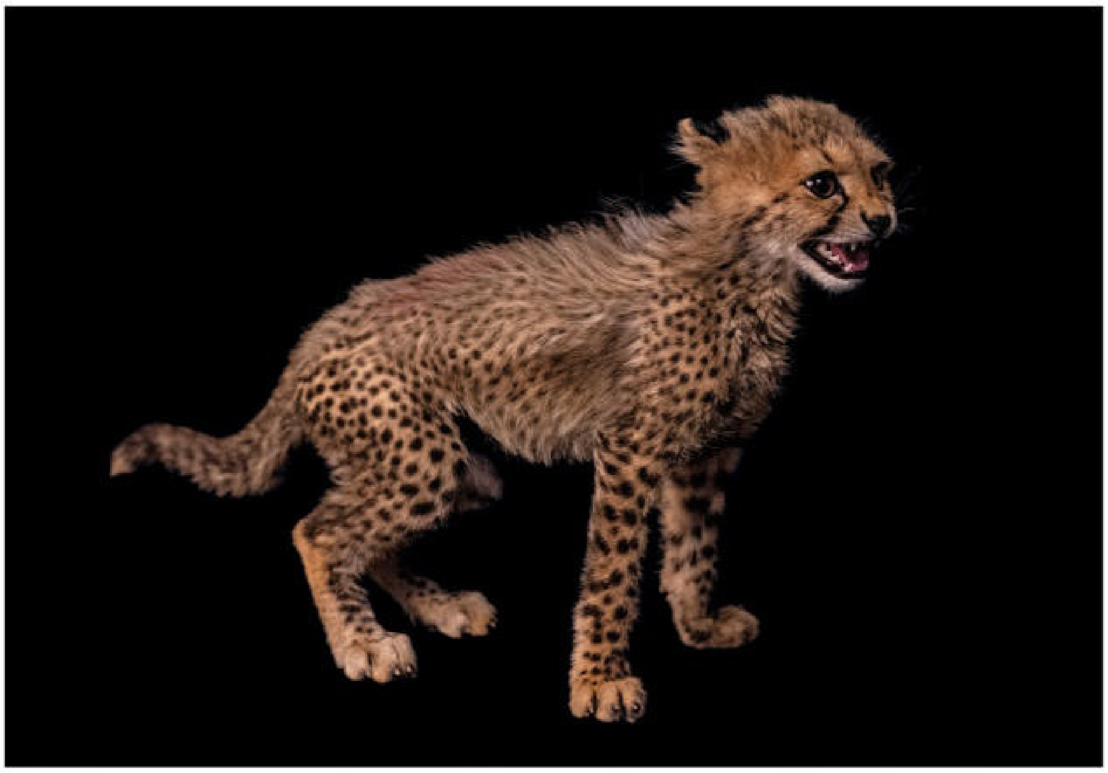
"I welcomed him. He was a friend," Guuleed says. "Cabdi Xayawaan dragged me into this. I have 18 kids and four wives." Guuleed pleads for a second chance.

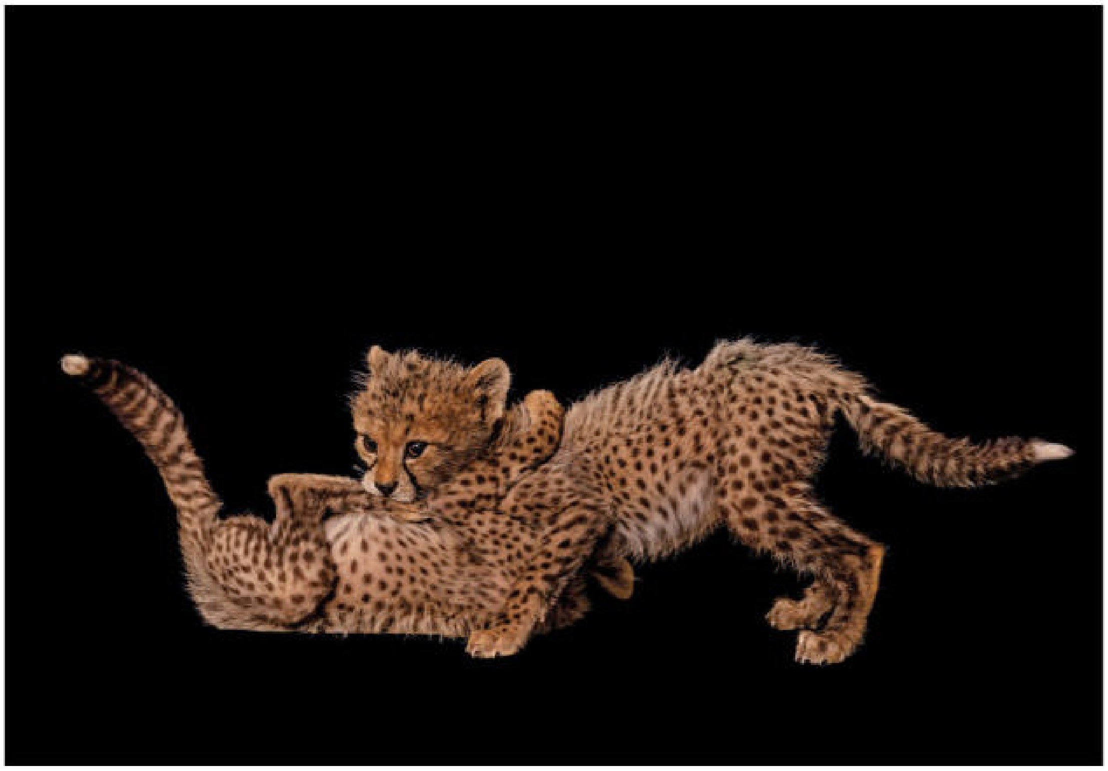
Cabdi Xayawaan, sitting on the bench behind

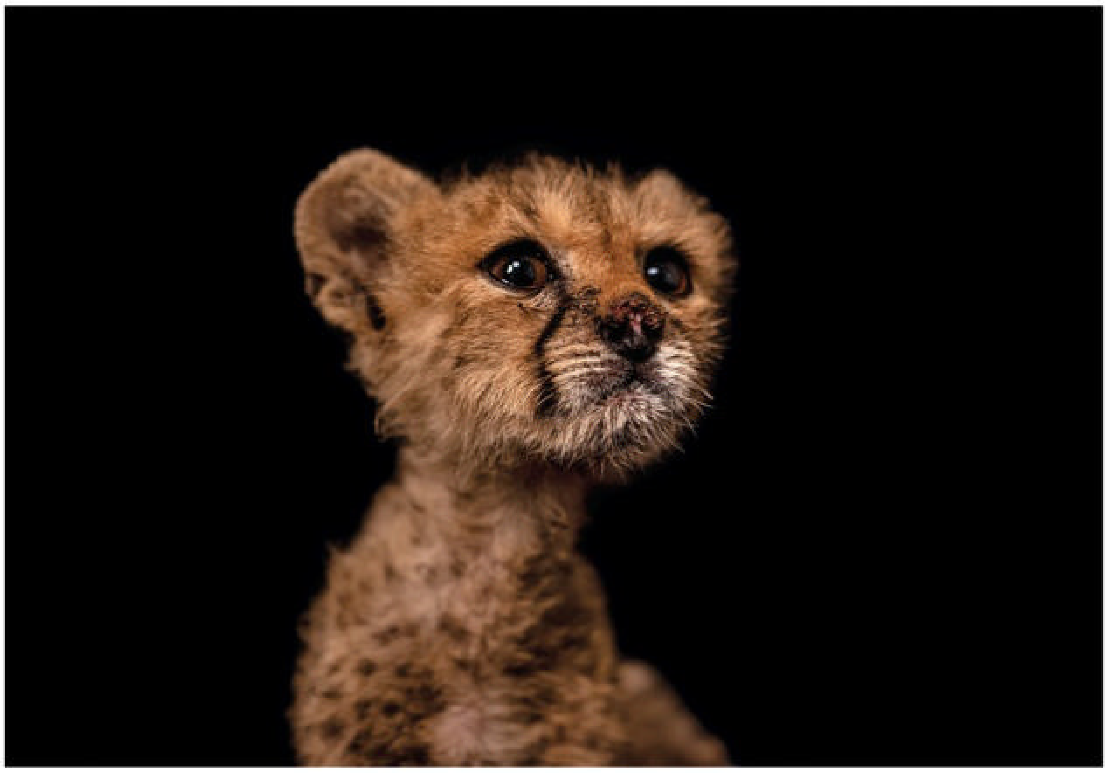
**The National Geographic Society,** committed to illuminating and protecting the wonder of our world, has funded Timothy Spalla's research on cheetah trafficking since 2019 and Explorer Nichole Sobecki's current work in the Democratic Republic of the Congo.

ILLUSTRATIONS BY JOE MCKENDRY

Five rescued cubs are corralled in a tent in front of a heater. Just six weeks old, they require feeding every few hours. One CCF veterinarian at a time serves as the primary caretaker for very young cubs, even sleeping next to them. The organization houses and cares for all of Somaliland's confiscated cheetahs—nearly 60 as of mid-2021.







# Rescue stories

RIGHT

**FREYA** Before his rescue, Freya had been kept in a wood-and-wire cage and was skinny and dehydrated. Now healthy, he loves climbing on logs, sitting on high platforms, and playing with toys.

TOP LEFT

**IDRIS** When he was brought to a CCF rescue center with his sister Elba, Idris was skittish around people. He would let Elba investigate new situations first, staffers say, but now he has grown more confident.

MIDDLE LEFT

**LINK AND ZELDA** These siblings were among 10 cubs rescued last October after the high-profile arrest of Cabdiraxmaan Yusuf Mahdi, better known as Cabdi Xayawaan, on wildlife trafficking charges. Named after characters in Nintendo's Legend of Zelda, the pair are inseparable—even when Link annoys Zelda with his roughhousing.

BOTTOM LEFT

**SAN** Called "Nose" in Somali, San is another of the cubs rescued in Cabdi Xayawaan's case. She had a badly injured nose and cried at first, but since she's been housed with Link and Zelda, she's settled down.

Storm, Guhad, and Leo (left to right) rest on a wooden shelter in their enclosure at a CCF rescue center. Trafficked cheetahs typically are taken from the wild as babies; because they never learned to hunt, they can't be returned to the wild. Until Somaliland's rescued cheetahs have a protected reserve where they can live in natural surroundings, they'll be confined here.

Guuleed, doesn't react. He has three past cheetah-related convictions and a reputation as Somaliland's top smuggler of the cats. His nickname, Cabdi Xayawaan (pronounced AB-dee HI-wahn; in Somali, *c* is silent and *x* sounds like *h*), means "Cabdi Animal." When he stands to give his side of things, he speaks with relaxed indifference.

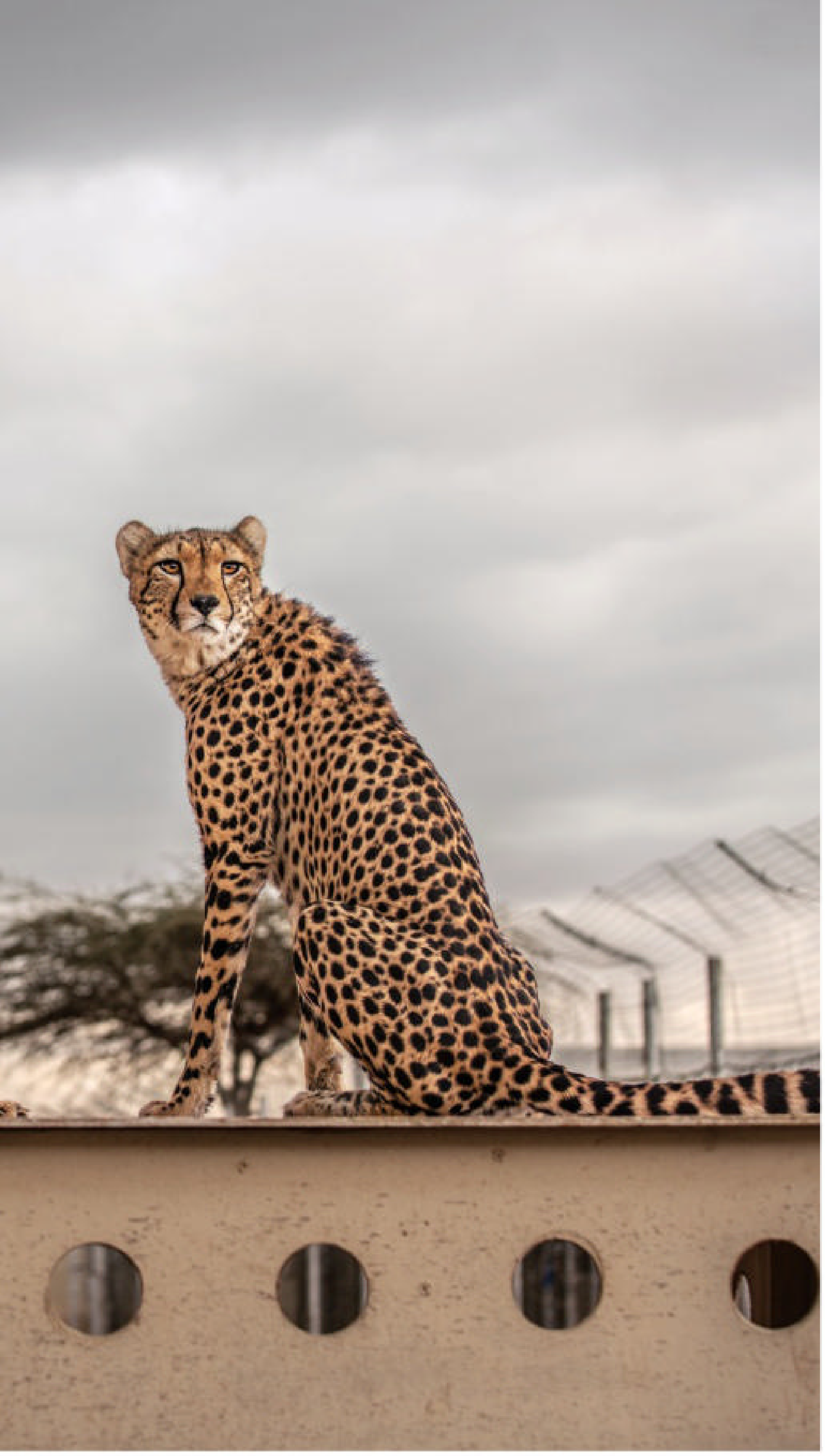
Yes, I served time in prison for cheetah smuggling in the past, he says, but I'm no longer involved in the trade. The cubs belonged to Guuleed. "There's no clear evidence I was involved."

The judge doesn't look convinced.

**FEWER THAN 7,000 ADULT CHEETAHS** are left in the wild, according to recent estimates, most in southern and eastern Africa. International commercial trade of cheetahs has been banned since 1975. Even so, from 2010 through 2019, more than 3,600 live cheetahs were for sale or sold illegally worldwide, with only about 10 percent intercepted by law enforcement, says Patricia Tricorache, a researcher with Colorado State University who's been tracking the cheetah trade for 15 years. Taking cheetahs from the wild has been illegal in Somaliland since 1969.

Habitat loss and retaliatory killings by herders when cats prey on their livestock are the biggest threats to the cheetah's survival, compounded by the illegal trade in cubs. Babies, often still

Support Wildlife Watch, a reporting project that shines a light on wildlife exploitation, by donating to the National Geographic Society at *natgeo.org/joinus*.



nursing and dependent, are snatched from the wild while their mothers are hunting or when a lactating mother is tracked back to her den. On foot and by camel, car, and boat, traffickers move the cubs through the Horn of Africa and across the narrow Gulf of Aden to Yemen, a journey of 200 miles or more that can take weeks. Cubs that survive are sold as pets in Saudi Arabia, the United Arab Emirates (U.A.E.), Kuwait, and other Gulf countries.

Somaliland is believed to be the center of the cheetah trade because of its easy access to the animals in Ethiopia and Kenya, its nearly 500-mile coastline, and its proximity to Yemen. Trade of all kinds, legal and illegal, has flowed across the Gulf of Aden for millennia. Today cheetah cubs, gemstones, humans, and more are smuggled out of the Horn of Africa, and guns, explosives, and ammunition are smuggled in.

THE PROSECUTOR, Cabdiraxmaan Maxamed Maxamud, springs to his feet, holding out Cabdi Xayawaan's phone, which was confiscated after the arrests. He begins to play audio messages the defendant had recorded on his phone and sent to his contacts. One is of Cabdi Xayawaan three months earlier, telling an associate in Ethiopia to find him cheetah cubs. In another, he discusses a money transfer with a contact in Yemen. The prosecutor shows the judge photos and videos of cheetah cubs on the phone—some local, some from Ethiopia—as well as photos of weapons Cabdi Xayawaan had requested from Yemen.

My old contacts keep sending me photos, asking me to find cheetah buyers, Cabdi Xayawaan says, beginning an elaborate explanation. He admits that he sometimes forwards those photos to the Yemeni—but not because he's trying to broker a deal, he insists. The Yemeni, Cabdi Xayawaan explains, owes him $80,000 for fuel but doesn't have enough money to settle the debt. If the Yemeni could get some cubs and sell them, he'd have the money he owes me, Cabdi Xayawaan says. "Whenever I ask for my $80,000, [he] asks for more photos. [He] has other buyers, so if he can sell more cubs, he can get the $80,000."

The prosecutor calls Cabdi Xayawaan a "habitual offender," telling the judge, "He's a criminal who has made the illegal wildlife trade part of his career."

In November, Guuleed and Cabdi Xayawaan were found guilty. Guuleed, who had no criminal record, was sentenced to a year in prison. Cabdi Xayawaan got four years, a record sentence for an environmental crime in Somaliland. It was a milestone for Somaliland's justice system—one that law enforcement and political leaders hoped would be enough to deter cheetah smuggling.

The 10 cubs now live in a rescue center in Hargeysa run by the Cheetah Conservation Fund (CCF), a nonprofit headquartered in Namibia that began working with Somaliland in 2011, when the government asked for help caring for confiscated cheetahs. By mid-2021, CCF had three facilities in Hargeysa holding nearly 60 cheetahs and one leopard. Because they were taken from the wild so young, none of these

‘In the smuggling trade, if you have a drop of mercy in your body, this work isn’t for you,’ one cheetah broker says.

animals are equipped to survive in the wild; they must spend the rest of their lives in captivity.

**THE APPEAL OF CHEETAHS** is no mystery. As cubs, they have huge round eyes, fuzzy little bodies, and Mohawk-like ridges of fur down their backs. As adults, they’re sleek, speedy, and regal, less aggressive than lions or tigers, and they purr like overgrown house cats.

Throughout history, cheetahs have been status symbols. A painting in the tomb of Rekhmire, an ancient Egyptian vizier, shows foreign visitors bringing tributes to the Pharaoh Thutmose III, including a cheetah on a leash. A Renaissance fresco in a Florentine palace shows a teenage Giuliano de’ Medici riding horseback with a cheetah seated behind him. Jazz Age burlesque star and French Resistance agent Josephine Baker could be seen walking her cheetah, Chiquita—an occasional participant in her stage act—down the Champs-Élysées.

Today Instagram is the place to see and be seen with a cheetah. Many public posts of pet cheetahs are from wealthy people in Persian Gulf states who use cheetahs as prestige props. There are photos of cheetahs with Lamborghinis and Rolls-Royces, cheetahs alongside sparkling swimming pools, and cheetahs posing with sumptuously dressed owners.

Instagram is also where many dealers post photos of cubs for sale, Tricorache says. (Snapchat, where posts disappear after a certain period, and TikTok, which hosts mainly short videos, are also used now, she says.)

Instagram did not respond to requests for comment.

**SOMALILAND** declared independence from Somalia, its neighbor to the south, in 1991 amid a civil war. Unlike Somalia, it’s a functioning, relatively stable democracy. Still, there are notable challenges. It has informal relations with several countries but officially is not recognized as a nation by the international community—a key goal of Somaliland’s government, now led by President Muuse Biixi Cabdi. Somaliland lacks infrastructure, has a per capita GDP of well below a thousand dollars a year, and depends economically on remittances from abroad. In addition, increasingly frequent droughts wipe out entire herds of livestock, the cornerstone of Somali lives.

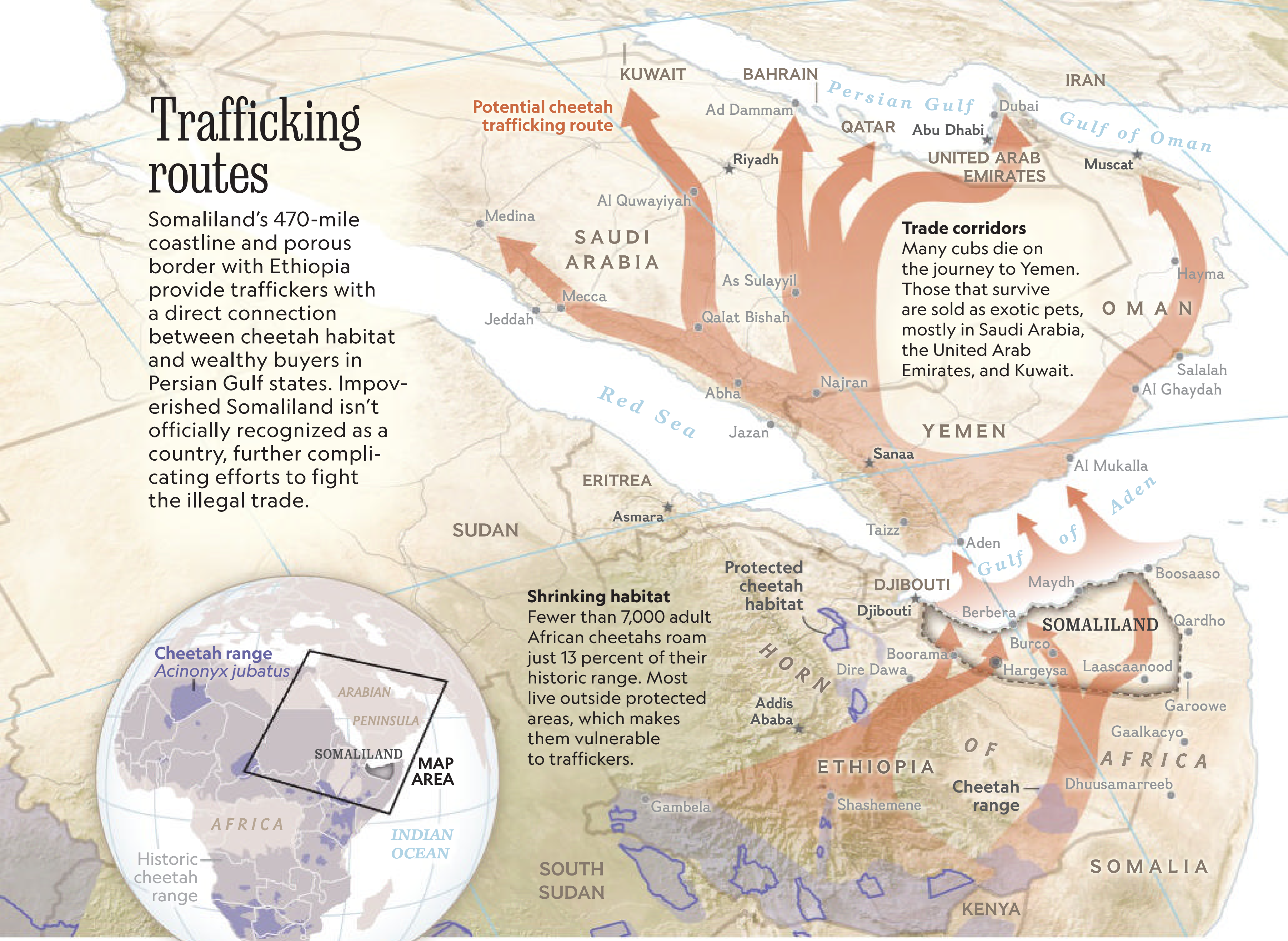
Despite these obstacles, the Somaliland government has taken on the illegal cheetah trade with more zeal than most countries have shown in dealing with any type of wildlife crime.

“Although we are a young country, an emerging country, still we are a country that [doesn’t] want to see wildlife suffering and wildlife trade,” says Shukri Haji Ismail Mohamoud, the minister of environment and rural development.

Her ministry is cracking down on cheetah smuggling, working with Somaliland’s coast guard, army, parliament, attorney general, and Ministry of the Interior, which oversees domestic security. It’s a fight to protect Somaliland’s natural heritage, boost peace and stability, and gain international recognition as an independent state governed by the rule of law.

Somaliland’s progress in developing its governmental institutions is occurring against the backdrop of a clan system that long has been the foundation of social organization, community security, and dispute resolution. This sometimes brings clan elders, who retain influence and respect, into conflict with civil authorities working to modernize the justice system and conservation policies.

Resolving disputes in particular has been the domain of clan elders, and they generally resist attempts to submit their kin to the formal legal system. Elders often pressure officials and civil servants to step aside and let *xeer,* or traditional law, decide the outcome. When it comes to suspected wildlife trafficking, clan interference and



# Trafficking routes

Somaliland's 470-mile coastline and porous border with Ethiopia provide traffickers with a direct connection between cheetah habitat and wealthy buyers in Persian Gulf states. Impoverished Somaliland isn't officially recognized as a country, further complicating efforts to fight the illegal trade.

**Trade corridors**
Many cubs die on the journey to Yemen. Those that survive are sold as exotic pets, mostly in Saudi Arabia, the United Arab Emirates, and Kuwait.

**Shrinking habitat**
Fewer than 7,000 adult African cheetahs roam just 13 percent of their historic range. Most live outside protected areas, which makes them vulnerable to traffickers.

SCALE VARIES IN THIS PERSPECTIVE. THE DISTANCE BETWEEN HARGEYSA AND RIYADH IS 1,050 MILES.
CHRISTINA SHINTANI, NGM STAFF. SOURCES: PAUL EVANGELISTA, DARIN SCHULTE, PATRICIA TRICORACHE, AND NICHOLAS E. YOUNG, NATURAL RESOURCE ECOLOGY LABORATORY, COLORADO STATE UNIVERSITY; AFRICA RANGE-WIDE CHEETAH CONSERVATION INITIATIVE; GREEN MARBLE; OPENSTREETMAP

corruption can prevent cases from entering the formal legal system, says Erica Marsh, an expert on the Horn of Africa, though this has started to change since the passage of Somaliland's 2015 Forestry and Wildlife Conservation Law.

Without diplomatic recognition, Somaliland can't directly access international aid and development funding. This has left law enforcement lacking cars to track suspects, boats to patrol seashores, and radios to communicate with each other. It also makes it difficult for the environment ministry to expand its reach beyond Hargeysa: Few people in the remote, rural areas where the smuggling originates are aware of wildlife protection laws. To pastoralists for whom cheetahs usually are nothing more than a threat to livestock, selling cubs differs little from selling goats.

MAHDI FAARAX DUGSIYE is 38 years old. He has a wife, seven children, 40 goats and sheep, and a camel. He's now known in the area around Bown, where he lives, as the "cheetah protector." But several months earlier, he shot one dead.

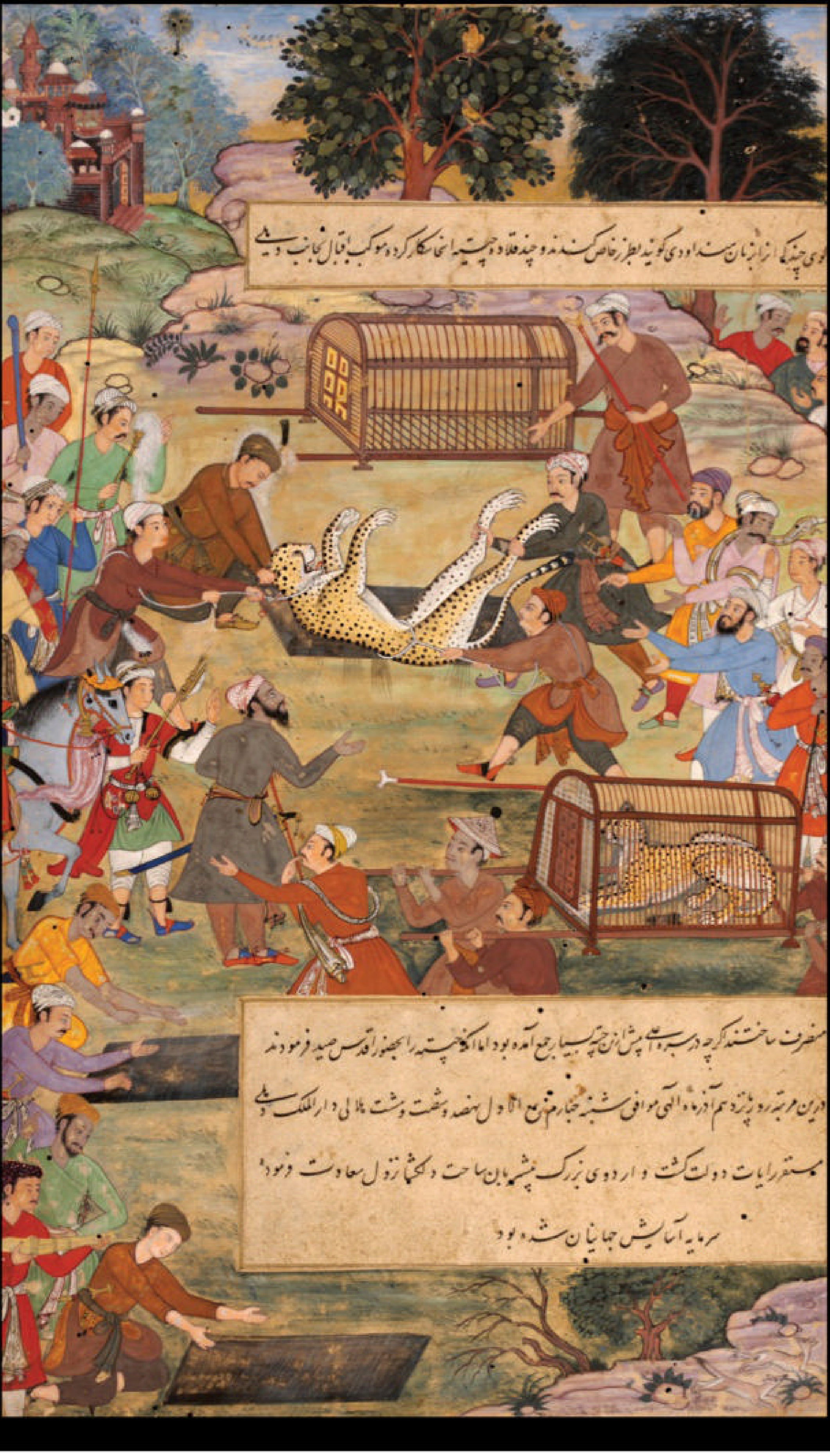
Late one afternoon, he heard a commotion. As he ran toward his herd, he saw a cheetah eating a goat. It was the goat that had been providing milk for his youngest son. "I felt so bitter I nearly cried. I had to take revenge," he says. He rushed for his gun, a rifle he inherited from his father. The cheetah was still there when he returned. He fired a single bullet and hit her in the side. She ran, but he knew she'd soon be dead.

"I kissed the gun. I have succeeded," Dugsiye says, recounting the day. For Somali pastoralists, wealth is the size of their herd, and losing a goat is like losing cash. Some in that situation would go looking for cheetah cubs—they know there's a market for them, and selling baby cheetahs can help offset the loss of livestock.

But Dugsiye was satisfied with revenge. When he was young, his father owned 500 cattle, goats, and sheep, a herd of camels, and a farm. If a cheetah killed one of his animals, he'd brush it off, Dugsiye says. It was only one out

# Captive cheetahs through history

Pet cheetahs today are most likely to be found in wealthy Arab households. But they've long been the playthings of high society around the world, from ancient Egyptian pharaohs and Genghis Khan to Italy's Renaissance nobles, such as the Medicis.



LEFT

**AKBAR THE GREAT** This 16th-century ruler of Mughal India hunted deer with cheetahs, once found across the subcontinent. In a painting from the 1590s, he's capturing wild cheetahs, trapped in pits to be brought to his palace and trained for the hunt.

RIGHT, CLOCKWISE FROM TOP LEFT

**HAILE SELASSIE I** Ethiopia's last emperor stands with his pet cheetahs at the Jubilee Palace in 1962.

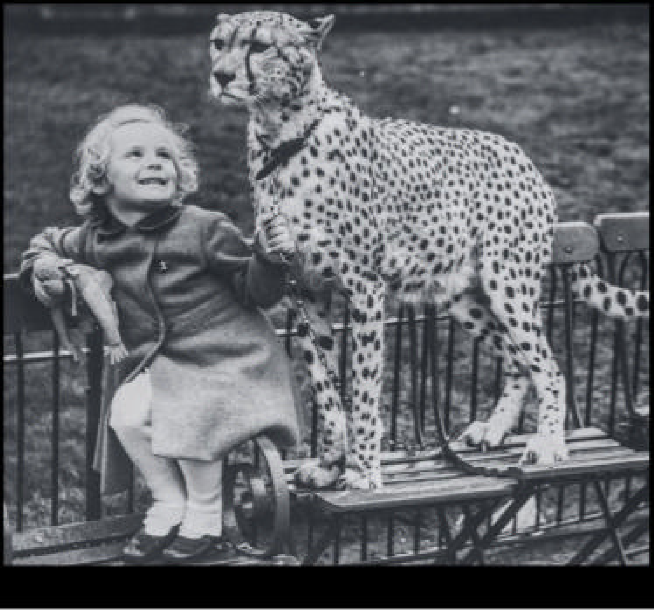
**JOSEPHINE BAKER** The cabaret star poses with her cheetah, Chiquita, in the 1930s. A gift from a club owner, Chiquita became part of Baker's act and later traveled with her.

**PHILLIDA THEOBALD** Four-year-old Phillida sits in London's Hyde Park with Spot, brought back from Kenya by pilot Guy Wilfred "Bill" Harben before World War II.

**RAYMOND CORDIER** Smoking a cigar in his Parisian shop, Cordier had a waiting list of "40 jet-set wives" in France standing by to buy cubs, a newspaper reported in 1969.

**CHARLENE CHAPMAN** The soprano singer is shown with pet cheetah Flossie in her New York State home in 1956.

"AKBAR ASSISTS IN CAPTURING A CHEETAH," FROM THE *AKBARNAMA*, BY TULSI AND NARAYAN, VICTORIA AND ALBERT MUSEUM, LONDON



CLOCKWISE FROM TOP LEFT: VINTAGE IMAGES/ALAMY STOCK PHOTO; TRANSCENDENTAL GRAPHICS/GETTY IMAGES; HULTON-DEUTSCH COLLECTION/CORBIS/CORBIS VIA GETTY IMAGES; JEAN-CLAUDE DEUTSCH, *PARIS MATCH* VIA GETTY IMAGES; BETTMANN/GETTY IMAGES

Instagram is where many cheetah owners post photos of their cats—and where many dealers offer cubs for sale.

of several hundred. It was just nature's way of things, his father would say.

Today Dugsiye's herd is a fraction of that, and the farm is gone. Drought comes often, and rainfall is erratic. There's flash flooding when the rain does come, and storms—such as Tropical Cyclone Sagar in 2018—can be deadly. That storm killed at least 25 people in Somaliland and half the livestock in the region of Awdal.

The land can't support domestic or wild animals as it once did, and because drought has made good grazing and vegetation scarce, prey animals such as antelope and warthogs have become less abundant. That forces cheetahs to look for other sources of food—sometimes goats and sheep that pastoralists have had to bring deeper into cheetah habitat to find good grazing.

Officially, cheetahs disappeared from Somaliland decades ago, but most herders say they see them at least occasionally. Dugsiye spots the cats prowling the outskirts of Bown roughly once a month, he says, sometimes more, and there's at least one attack on his animals every year.

The day after Dugsiye killed the cheetah, Cabdinasir Hussein, director of wildlife at the environment ministry, happened to be driving through Bown and came upon a dead cheetah on the roadside. A herder identified Dugsiye as the shooter, and he was arrested. It was the first time Dugsiye learned it was anyone's job to protect wildlife.

Few people in Somaliland are aware of its wildlife law, especially in rural areas. Low literacy rates and nomadism make it difficult to notify the pastoralists, the people most likely to interact with wildlife, says Cabdilahi Xasan Warsame, the mayor of Xariirad, a town near the Ethiopian border where people come to sell cheetah cubs. He says he believes that with education and sensitization about the importance of cheetahs, communities "will become their protectors, not their harmers," especially if clan elders can be persuaded to take the lead.

Dugsiye was released without charges, after getting a lecture about the law and how cheetahs deserve protection because they're a vital part of Somaliland's natural heritage. "I promised I'd never shoot another cheetah again," he says, adding that he vowed to report anyone who does.

His newfound dedication has been tested. Not long after his arrest, he lost two more of his goats—one that was nursing and another that was pregnant. But, he says, as long as he can feed his children, he'll remain an advocate for cheetahs.

POVERTY DRIVES SOME PEOPLE to kill or poach cheetahs, but greed drives top traffickers. "In the smuggling trade, if you have a drop of mercy in your body, this work isn't for you," says one cheetah broker, a jumpy khatseller with bloodshot eyes. He's describing Cabdi Xayawaan. He adds: "He's a man who doesn't have a soft heart."

Sitting under a shady mango tree as baboons scamper down the dry riverbed behind him, the broker explains how he acted as an intermediary between herders, who poach the cubs just across the largely unmanned border in Ethiopia, and Cabdi Xayawaan, who smuggled them to Somaliland's coast and out of the region. "I was like the pipe," he says, pointing to a concrete water pipe a few feet away. Just the conveyor of cubs, not the one collecting or selling them.

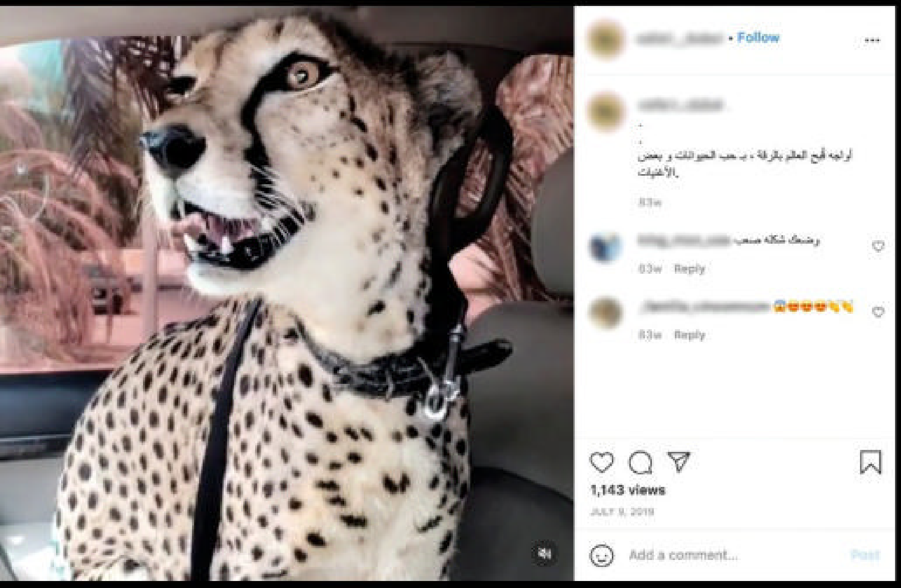
Cabdi Xayawaan is known among everyone from government ministers and senior military officers to town mayors, fishermen, and farmers. "He's the worst trader," says Col. Yuusuf Iimaan Diiriye, commander of the army garrison that oversees the western Somaliland regions of Sahil and Awdal. "He's the man who is making the cheetah extinct in this region."

Cabdi Xayawaan often operated near the towns of his childhood in Sahil, people in the area say. He knows the routes where he'd be least likely to run into patrols, the beaches more (and less) likely to have coast guards, and the towns with

# Photo props

Cheetahs in Persian Gulf countries are photographed as accessories to fancy cars or fashionable alternatives to house cats. Owning a cheetah often is illegal, but people with public social media accounts and tens of thousands of followers post photos of them anyway. Despite the association with luxury, many pet cheetahs are stressed and may be malnourished. Below, Instagram handles are blurred to avoid promoting such accounts.

For those who buy pet cheetahs, "the novelty wears off quickly, aside from the picture you get," says veterinarian Hollis Stewart, who has cared for captive wildlife in Dubai.



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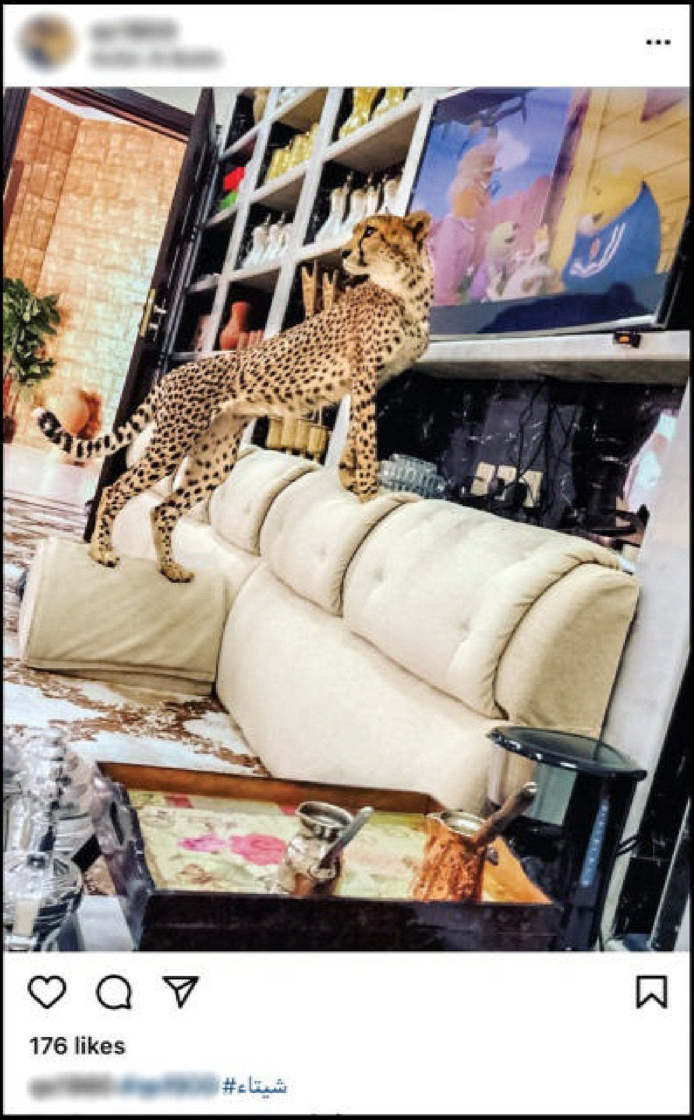

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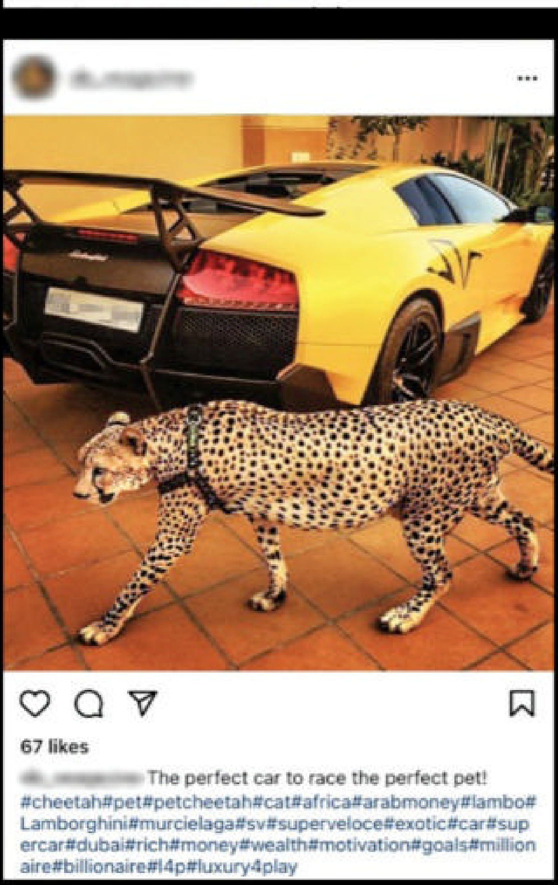

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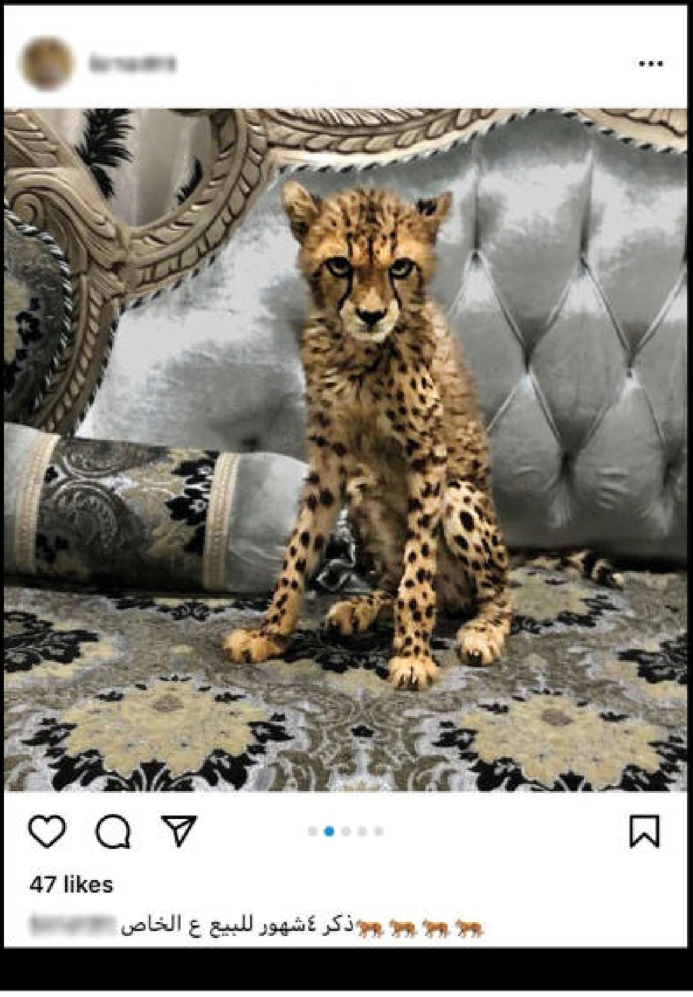
[redacted] The perfect car to race the perfect pet! #cheetah#pet#petcheetah#cat#africa#arabmoney#lambo#Lamborghini#murcielaga#sv#superveloce#exotic#car#supercar#dubai#rich#money#wealth#motivation#goals#millionaire#billionaire#l4p#luxury4play



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Social media sites like Instagram also act as a marketplace. The caption at left says, "Four-month-old male cheetah for sale. Contact in-box." Cheetahs aren't easy to breed in captivity; most pets were poached from the wild.

Somaliland Coast Guardsman Cilmi Xaamud Axmed (at center) climbs aboard a Yemeni boat to check fishing licenses as part of a routine patrol off Lughaye. Yemen is just hours away by boat, making these waters a busy trade route for trafficking—of humans, gems, weapons, and wildlife. The coast guard is the last chance to intercept smuggled cubs before they're out of Somaliland's reach.

people he could pay to be lookouts. Law enforcement officers have linked him to more than 20 incidents of cheetah smuggling in Sahil alone since 2012. Even so, before the case last fall, only three prior arrests had led to convictions.

"He's a politician with a wide network," says a driver on the Sahil coast who says he runs into Cabdi Xayawaan at least twice a month. Several times, he says, he has seen cheetah cubs—and even occasionally lion cubs—in Cabdi Xayawaan's car. The driver says Cabdi Xayawaan often travels with young men, some of whom are armed and some of whom seem drunk—a taboo in Islamic Somaliland, where alcohol is illegal.

"To him, nothing is haram," Diiriye says, using the Arabic word for "forbidden."

Cabdi Xayawaan got his start more than a decade ago, working with another trafficker, according to Timothy Spalla, a National Geographic Society–funded investigator who with his team has been researching the cheetah trade in the Horn of Africa and the Middle East. Cabdi Xayawaan quickly established connections with Arab buyers and overtook his former employer.

Described as intelligent and secretive by an army officer who once arrested him, Cabdi Xayawaan had several SIM cards for his cell phone and a satellite phone and frequently changed cars, Spalla says. He knows how to gain loyalty and build his network, relying on charm and incentives—money, mainly.

"When he finds an opportunity in you, he'll immediately take your name and number," according to the middleman, who says Cabdi Xayawaan recruited him for his many connections with Somali nomads on the Ethiopian side of the border. "That's how he grows his network."

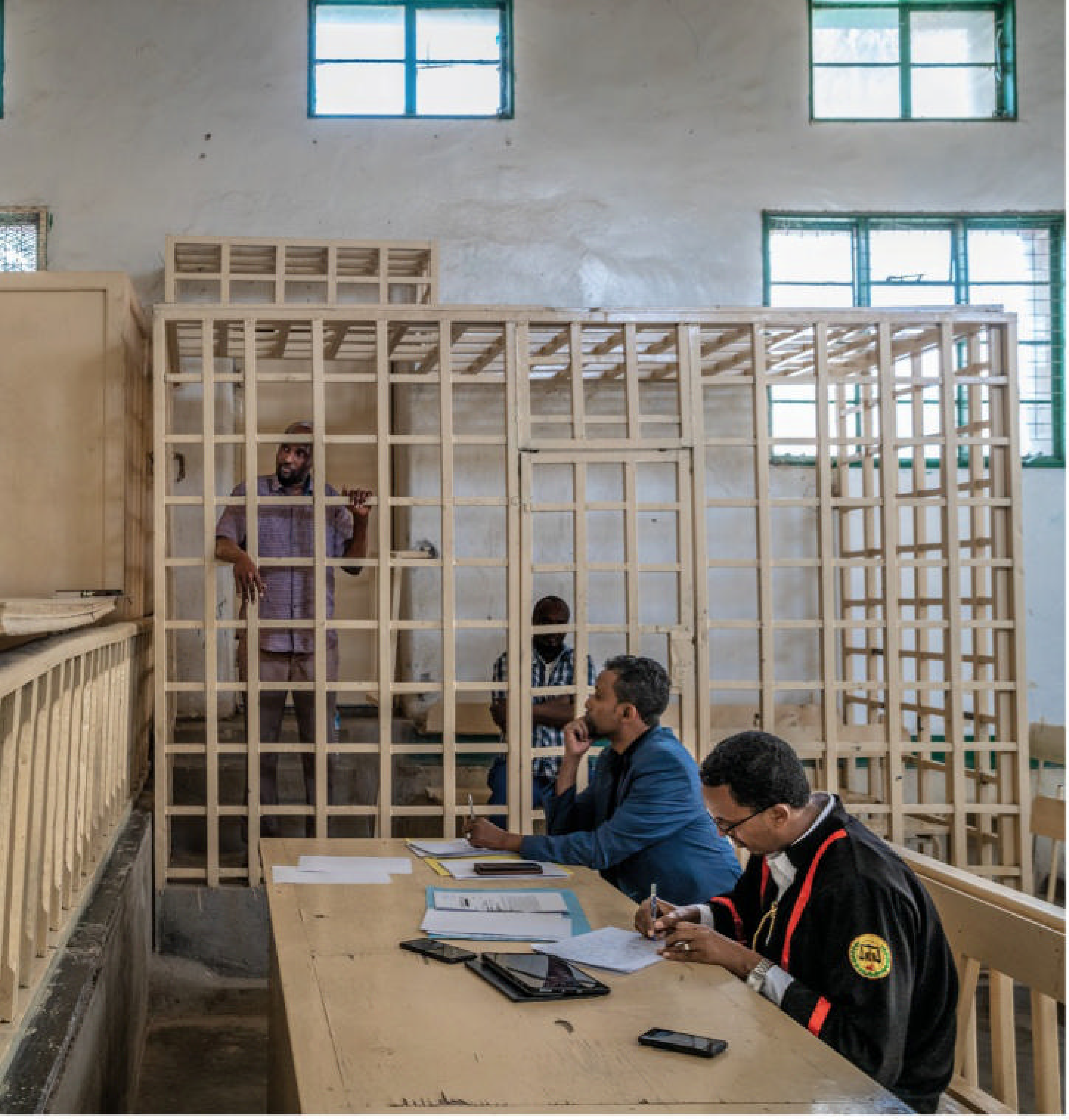
It's an extensive network. When law enforcement increased pressure in western Somaliland, Cabdi Xayawaan nimbly shifted his trade routes to the east. He mainly trafficked cheetah cubs, but he also smuggled an occasional lion or leopard cub and brought weapons and khat into Somaliland, according to eyewitnesses, associates, government officials, and law enforcement. He often took cubs to the beach himself to hand them to smugglers aboard boats bound for Yemen, say the driver and others who have seen him.

THE COAST GUARD station in Ceel Shiikh, a small town on the central coast, looks abandoned. A building with peeling paint stands in a large yard strewn with mechanical equipment. Officers posted there have no vehicle to get them from the station to locations along the beach used by smugglers. They have no radios and no satellite phones, and cell phone service can be weak, especially offshore. Their few small patrol vessels are really nothing more than fishing boats.

The coast guard officers and local leaders in Ceel Shiikh say they've known for years that Cabdi Xayawaan smuggled cheetahs by way of the town's beaches. He's well-connected, district commissioner Maxamed Jamac Colaad says, but so are those who aim to stop the smuggling.

"The nomadic community are like the radio and antennae," he says. "We work with them to get to know what the situation is." And one day four years ago, the situation was this: Cabdi Xayawaan was on his way to Ceel Shiikh in a red Toyota SUV with cheetah cubs, apparently planning to pass them to a boat just offshore that night.

With no car, the coast guard mounted an operation on foot. Officers knew from informants which route he'd be taking, so they lay in wait in the shrubs on both sides of the road. If he reached the beach, he'd carry the cubs across the sand and

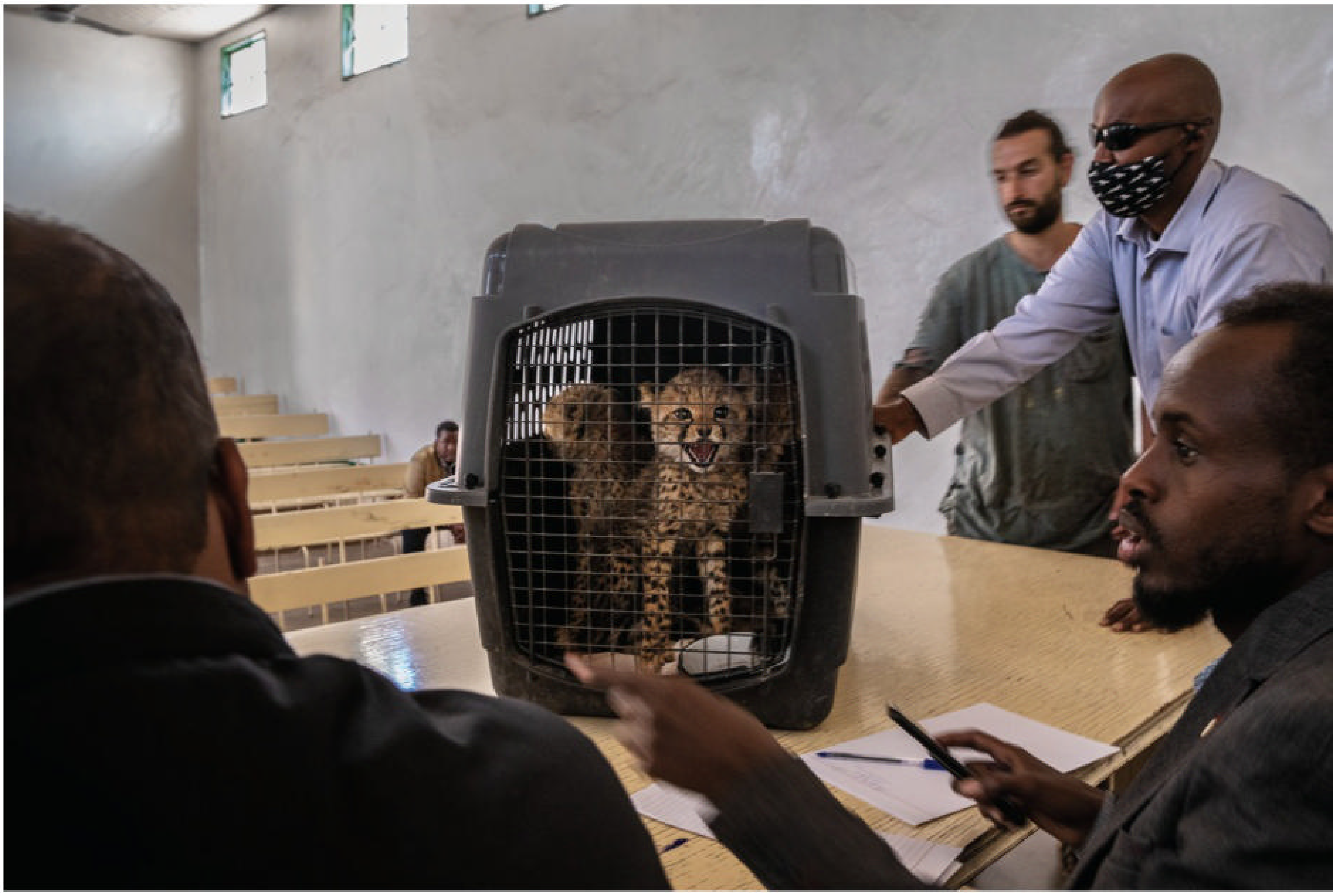


**LEFT**

On trial in Hargeysa for cheetah trafficking, Cabdi Xayawaan stands behind the bars of the courtroom cell as the judge speaks to him. Cabdi Xayawaan, who has three past convictions and a reputation as Somaliland's most prolific cheetah smuggler, pleaded not guilty.

**BELOW**

The judge (at left) looks at five of the 10 cheetahs confiscated in Cabdi Xayawaan's case and brought to court as evidence. Cabdi Xayawaan was found guilty last November and sentenced to four years in prison in a case that was widely seen as a landmark.



Lobikito Leparselu cares for his family's goats at dawn in northern Kenya. Here, as in Somaliland, losing livestock to cheetahs can be devastating. "I probably lose more than 20 a year out of my hundred," his father, Leparselu Lemongu, says. "That's my wealth, and I see it slipping away." Predation pushes some herders to capture and sell cheetah cubs to smugglers, but buyers seeking an exotic pet are the ones perpetuating the illegal trade.

into the warm surf of the Red Sea to hand them to Yemeni men who'd waded to shore from the boat. If the coast guardsmen couldn't stop Cabdi Xayawaan before the handoff, they'd have little hope of rescuing the cubs: The coast guard's boats are no match for the ones Yemeni smugglers use.

When Cabdi Xayawaan's car came bumping over the dirt and thorny brush, says the coast guard station's deputy commander, the officers drew their guns, jumped out of the bushes, and blocked the path. Searching the car, they found six cubs. Cabdi Xayawaan claimed innocence but was arrested. The case later was dropped; why is unclear.

Not every town in Somaliland is as under-resourced as Ceel Shiikh. In Berbera, which is home to a commercial port in development by the Emirati company DP World, a large coast guard presence has decreased cheetah smuggling significantly, says Col. Haaruun Saciid Cali, the commander of the Berbera coast guard, the largest sea command in Somaliland. "I can't say nothing gets out, but it's not common." When his troops go on patrol, it's in a 65-foot naval ship with two smaller skiffs for security.

"Our coastline is long, porous, and hard to police," says Axmad Maxamad Xaaji Du'ale, the governor of Sahil, and there aren't enough checkpoints on roads to the coast to stop illicit trade. In Berbera, though, the coast guard and police informant networks have helped improve security in recent years, forcing smugglers to find other exit points. The port is crucial to the Somaliland economy and to gaining future foreign investment, so "we're very, very serious about security," Du'ale says. "We are all seeking the goal of gaining recognition of the country."

The government also has commissioned an army unit to fight trafficking. The 18th Battalion, named after Somaliland's independence day, May 18, 1991, is based in the coastal town of Lughaye, another place Cabdi Xayawaan had used to move cheetah cubs out of Somaliland. The unit is tasked with preventing the trafficking of humans, wildlife, and, mainly, weapons.

One fisherman, who has been working along the coast for 30 years, says he's seen all kinds of smuggling out of Lughaye: humans, fuel, gems, cheetahs, leopards, lions, gazelles.

Not long ago, he says, when he was chasing a fishing net that was blowing away, he ran into three men with several cheetah cubs on the beach. Nearby were two wooden boxes with air

The U.A.E. bans private ownership of 'dangerous' animals, but some cheetah owners take advantage of a loophole that allows private zoos.

holes and open padlocks. The pickup boat was delayed, the fisherman says they told him, so they'd let the cubs out for fresh air.

He says he first saw cheetah smuggling in Lughaye around 2005 and that it became a hot spot, peaking around 2013. At the time, he saw cubs smuggled out at least once a month, sometimes once a week. The 2014 outbreak of war in Yemen and the Saudi-led blockade of its coastline, followed by the Somaliland government's crackdown on cheetah smuggling, temporarily slowed the trade, he says.

The fisherman recalls that he got to know Cabdi Xayawaan when the latter's car broke down one day in 2014, and that the two have crossed paths frequently. "He was one of the first smugglers I met," the fisherman says. "He's an open, sociable man who is often very generous."

The day Cabdi Xayawaan was stuck in town, they talked about their work. "Your food is from the sea, and mine is from the cubs," the fisherman says Cabdi Xayawaan told him. "So don't interfere." Then Cabdi Xayawaan gave him money.

IN THE COOL OF THE CONCRETE-WALLED court in Hargeysa, the prosecutor repeatedly brings his argument back to the evidence on Cabdi Xayawaan's phone—especially the messages between him and the Yemeni. On one day, bank records cited by the prosecutor show, the Yemeni sent Cabdi Xayawaan nearly $4,000. Not long after that, he received photos and videos of cheetah cubs. The prosecutor hits "play" on a video, and once again, cubs' chirps echo through the room.

No one knows where those cubs are now—whether they were some of the 10 brought to Guuleed's house and later rescued, whether they were put on a boat to Yemen and now live in a private menagerie at a villa, or whether they died where they were. Most cubs in the trade are fed only goat milk and meat as a substitute for nourishment from their mother, and it's likely many die of malnutrition and other illnesses along the way.

The routes smugglers use to move cheetahs from Yemen throughout the Persian Gulf aren't well known, but many cubs probably are driven across Yemen into Saudi Arabia, according to Tricorache. From there, they're distributed to buyers in-country or in Kuwait or the U.A.E.

The laws on keeping wildlife as pets in these countries can be hard to parse. The U.A.E., for example, banned private ownership of "dangerous" animals such as cheetahs in 2016. Some people surrendered their cats, but five years later many Emiratis still own them, a search of Instagram indicates. Some, it seems, use a loophole that exempts research centers, wildlife parks, and zoos—including private zoos, such as those owned by the ultrawealthy—from the ban. The U.A.E.'s environment ministry says it sets rigorous standards for zoo licenses and works with local authorities to "devise a coordinated, swift response to reports of illegal possession." Penalties include up to six months in prison and a maximum fine of $136,000.

In Kuwait, several cheetah owners declined to talk with *National Geographic* on the record for fear of getting into trouble with the law, even though they publicly share photos of their cheetahs with their thousands of Instagram followers.

Regardless of what it looks like in those photos, cheetahs have not been domesticated. Domestic animals—such as cats, dogs, sheep, and horses—arise out of generations of selective breeding, for companionship, food, or work. But cheetahs don't reproduce easily in captivity, says Adrienne Crosier, the biologist who manages the cheetah breeding program at the Smithsonian Conservation Biology Institute, in Virginia. Inconsistent reproductive cycles and the fragility of cheetah cubs make breeding them more of an art than a science, she says, adding that the majority of pet cheetahs "are coming out of the wild."

CABDI XAYAWAAN IS IN PRISON now, but it's not certain for how long. Last spring, months after the legal period to contest his conviction had passed, his case was reopened, for reasons that remain unclear. Also last spring, Guuleed, who paid a fine and served just part of his one-year sentence, died at home in Hargeysa shortly after his release, according to the Ministry of the Environment.

If Cabdi Xayawaan's conviction is reversed, one of Somaliland's biggest wins against the illegal trade in cheetah cubs will end instead, as so many wildlife crime cases around the world do—quietly and with little consequence.

As of late June, at least 150 cheetahs have been listed for sale this year. ☐

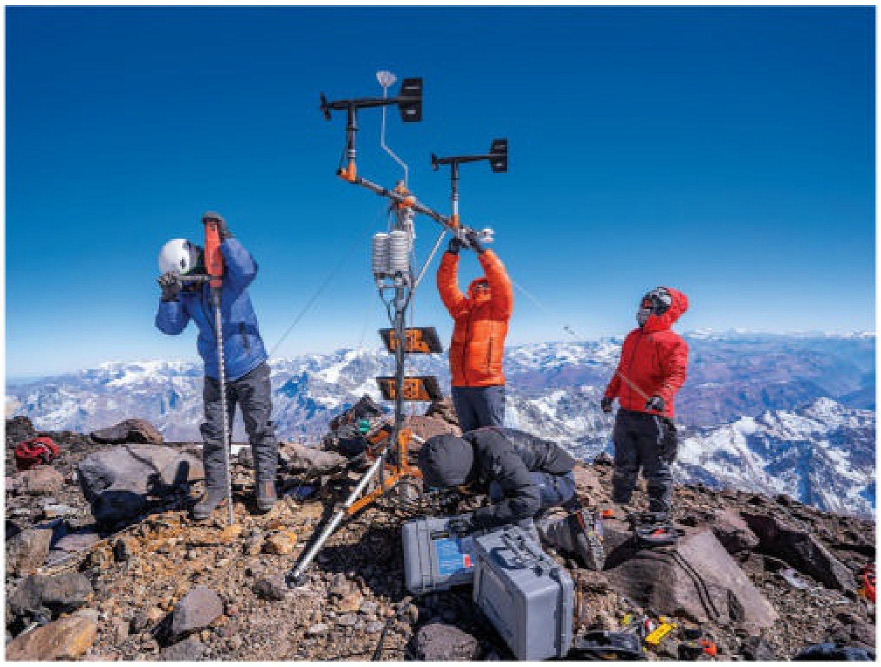
**Rachael Bale** is the executive editor of National Geographic's Animals desk and reports on wildlife crime. Photographer **Nichole Sobecki,** a National Geographic Explorer, focuses on humanity's connection to the natural world.

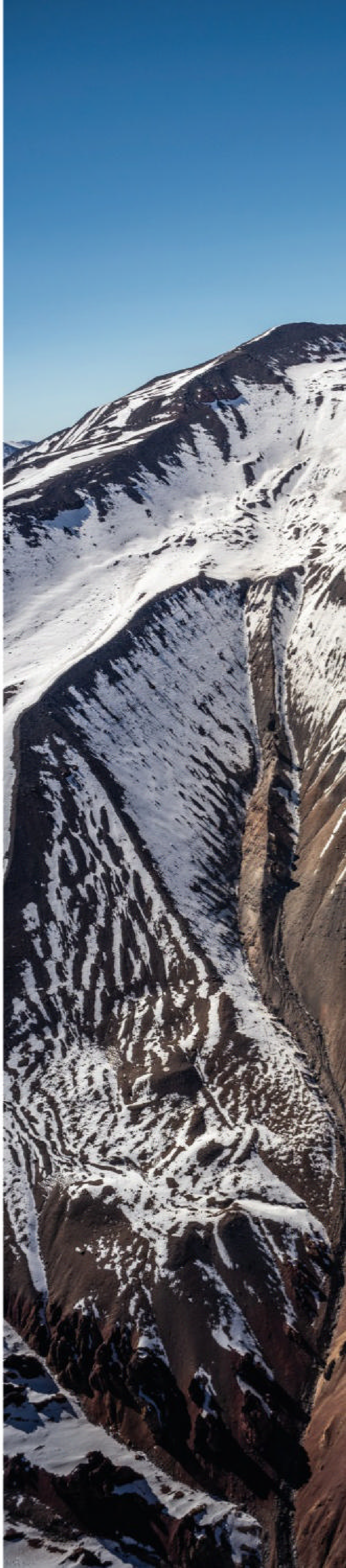
# TRACKING

BY SARAH GIBBENS
PHOTOGRAPHS BY ARMANDO VEGA

# THE MELT

High in the Andes, a National Geographic team installed a weather station that could help central Chile cope with the drought and warming that threaten its water supply.



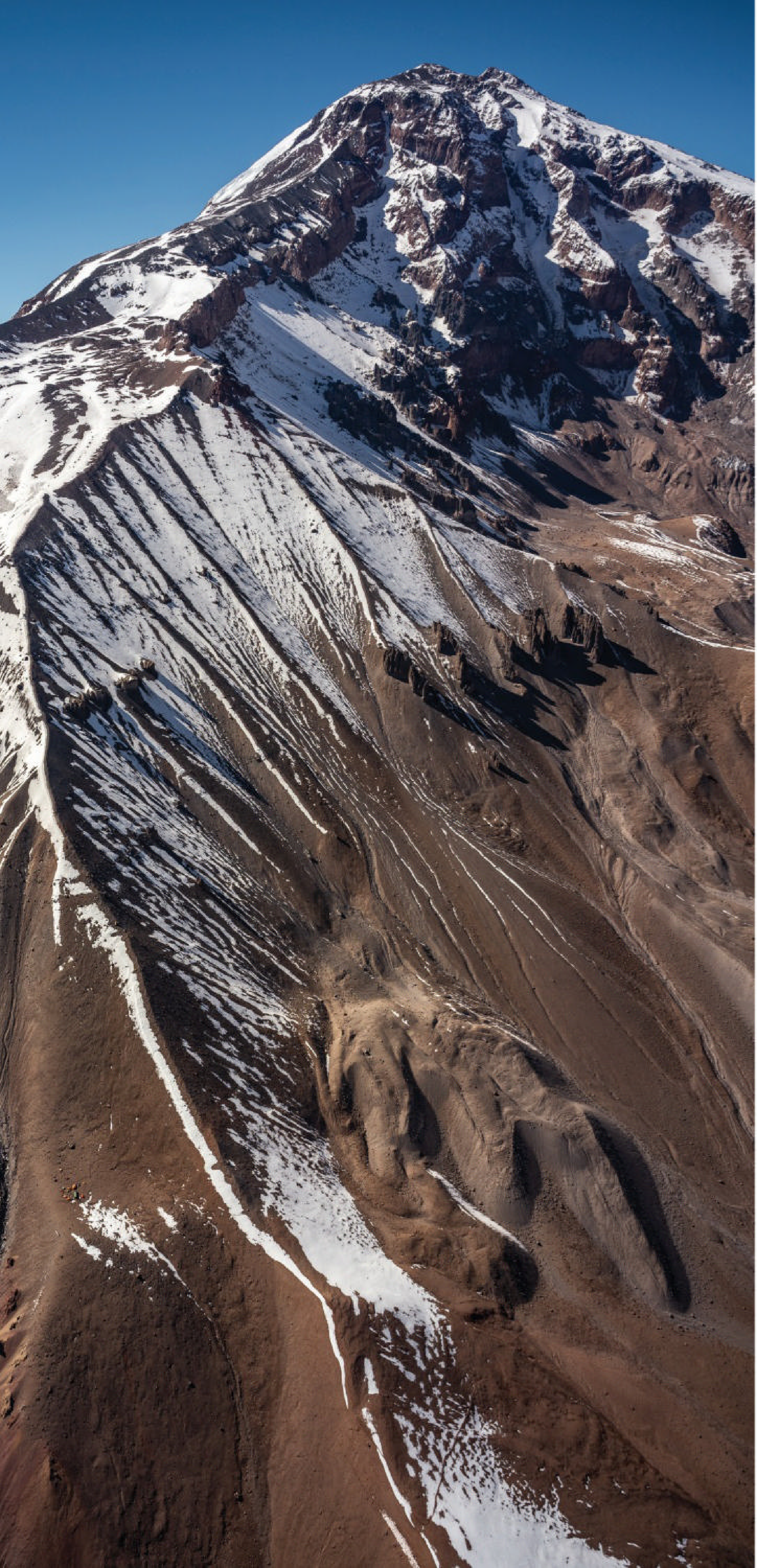


# AT A LITTLE OVER 19,000 FEET ABOVE SEA LEVEL ON THE CHILEAN MOUNTAIN OF TUPUNGATO,

Baker Perry and his fellow climbers were clobbered in the early morning hours by an unpredicted blizzard that pinned them in their tents with punishing winds and swirling snow. Perry, a climate scientist at North Carolina's Appalachian State University, was philosophical as he recalled it.

"It's part of the beauty of the mountains that it is so challenging. That's one reason there's not many stations up in some of these places," Perry says. "We want to see it at its stormiest and at its most challenging as well. That's part of the climate. We need to measure that."

Perry is a co-leader of an international team that in February braved a global pandemic and a 15-day trek and climb through dense snow to install a weather station just below the summit of Tupungato, a dormant volcano in the southern



**FAR LEFT**

Franco Buglio (at left), mountain guide Manuel Mira, Alejandra Espinoza (crouching), and Fernando Urbina install a weather station at over 21,000 feet, near the summit of Chile's Tupungato volcano. Buglio, Espinoza, and Urbina are from Chile's water department. Data the weather station collects will help clarify the impacts of climate change on an important water reservoir for central Chile.

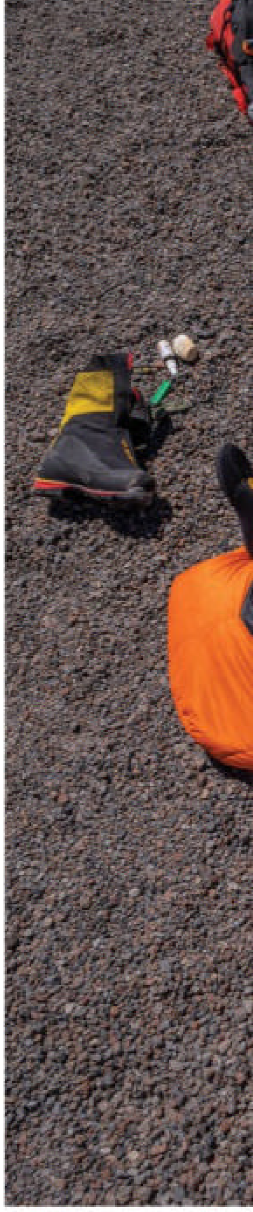
**LEFT**

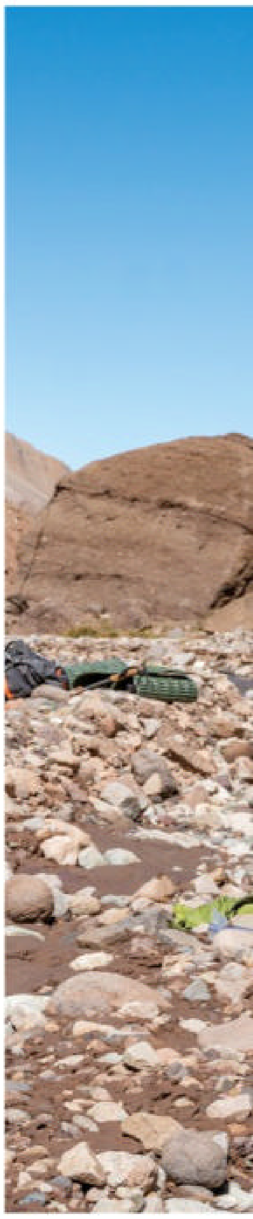
The top part of the route that the expedition took up Tupungato followed the skyline to the left of the summit. Snowpack and glacier melt from the volcano feed the Maipo River—for now. Climate change is reducing central Chile's rain and snowfall, resulting in an extended drought.

**PREVIOUS PHOTO**

Cinematographer Brittany Mumma (front) and photographer Armando Vega make the final push up Tupungato to install the Southern Hemisphere's highest weather station. It took 15 days to make the trip up and back, and more than a year of planning.

DIRK COLLINS





**CLOCKWISE FROM TOP LEFT**

Baker Perry, a climate scientist and mountaineer, adjusts an existing weather station at 14,600 feet on Tupungatito Volcano—just south of the larger Tupungato, where the expedition took place. Water and rock samples were also collected at Tupungatito.

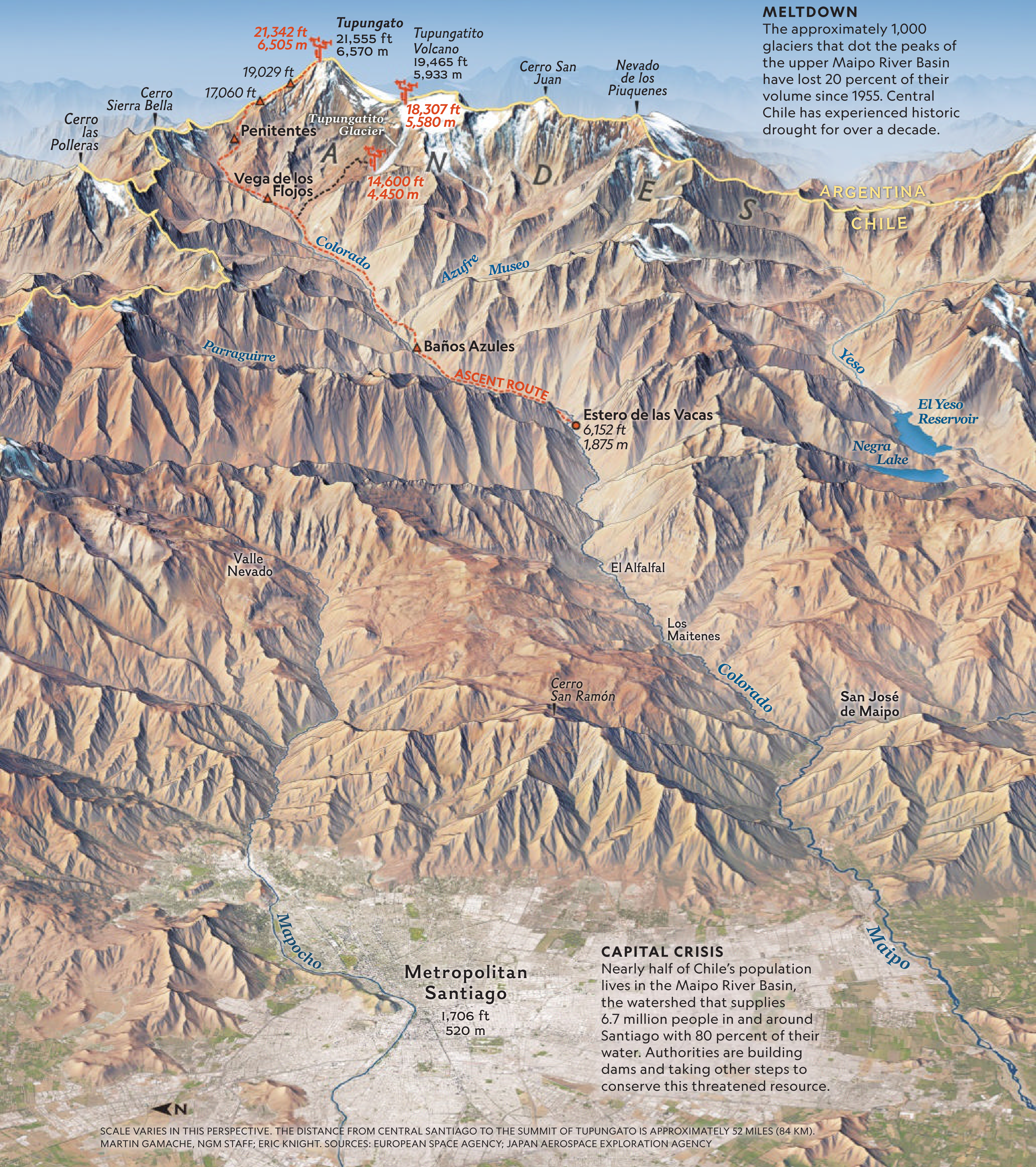
Espinoza, a geologist, rests on a pile of gear at about 19,000 feet. To ascend Tupungato, the team hiked over loose volcanic rock, trekked through deep snow, and navigated steep inclines, all while coping with the low oxygen of high altitudes.

Perry stops for a quick rinse on his way to the Penitentes camp at about 14,100 feet. Changes in the ecosystem and climate can be abrupt for climbers. The landscape, full of small shrubs and bushes, quickly transforms to high peaks, glaciers, and snow.

Expedition doctor Ignacio Navarrete administers a COVID-19 test to cinematographer Dirk Collins. Team members received at least four tests during the trip, which began in February, when COVID-19 vaccines were limited and many parts of the world were seeing spikes in cases.

# Watching the water

Tupungato, the sixth tallest mountain in Chile, rises in one of South America's most vulnerable water towers. Last February a National Geographic expedition placed the Southern and Western Hemispheres' highest weather station here. It will help scientists better measure and predict precipitation as climate change exposes the region to more drought and threatens the water supply for millions.



**MELTDOWN**
The approximately 1,000 glaciers that dot the peaks of the upper Maipo River Basin have lost 20 percent of their volume since 1955. Central Chile has experienced historic drought for over a decade.

**CAPITAL CRISIS**
Nearly half of Chile's population lives in the Maipo River Basin, the watershed that supplies 6.7 million people in and around Santiago with 80 percent of their water. Authorities are building dams and taking other steps to conserve this threatened resource.

SCALE VARIES IN THIS PERSPECTIVE. THE DISTANCE FROM CENTRAL SANTIAGO TO THE SUMMIT OF TUPUNGATO IS APPROXIMATELY 52 MILES (84 KM).

MARTIN GAMACHE, NGM STAFF; ERIC KNIGHT. SOURCES: EUROPEAN SPACE AGENCY; JAPAN AEROSPACE EXPLORATION AGENCY

Andes. Positioned where Chile meets Argentina, the weather station is the highest in the Southern and Western Hemispheres and will help scientists understand how rapidly the region's climate is changing. The expedition was organized by the National Geographic Society and supported by Rolex's Perpetual Planet Initiative.

With the temperature, wind speed, and snow depth data the station will gather, scientists hope to be able to better understand how central Chile and the country's capital, Santiago, will fare as climate change exposes the region to more drought—like the historic one it's in now—and shrinks the mountain water towers—glaciers and snowpack that act as stores of water.

"The stakes are really high now," says expedition member Tom Matthews, a climate scientist at Loughborough University in the United Kingdom. "There are millions of people living downstream of these water towers. They are part of this system we know very little about in terms of how it may respond as the climate warms."

Tupungato is Chile's sixth highest peak and the tallest mountain in the Maipo River Basin, the watershed that supplies the 6.7 million people living in and around Santiago. With better data on how much precipitation is falling on mountaintops like Tupungato, government officials will know how much water they have to allocate in a given year.

"Since 1982, I've been studying glaciers. Within my lifetime we've seen tremendous changes in glaciers and snow cover," says expedition co-leader Gino Casassa, the head of the Chilean government's glacier unit.

In a dry year, Casassa says, two-thirds of the water feeding the Maipo River at the end of the summer comes from glaciers that are shrinking.

Central Chile is a Mediterranean eco-region, climatically similar to places such as California. It lies south of the Atacama Desert, the driest nonpolar place on Earth, and is wedged between the Andes mountain range and the Pacific Ocean.

Chileans are used to dry years periodically; 2010 was one such year. But in 2011, and then in 2012 and 2013, there was still little rainfall. "Then came 2014," which was also dry, "and that was suspicious," says René Garreaud, a climatologist at the University of Chile, who was not involved with the expedition.

By 2015, Garreaud and his Chilean colleagues had determined the region was in what they dubbed a megadrought. It has endured for more than a decade. On average, since the drought began in 2010, a third less rain than usual has fallen each year. In 2019, the driest year since the drought's onset, there was less than a quarter of the normal rainfall.

Some natural variability influences rainfall totals over a decade, Garreaud says, but there's no doubt that climate change is contributing to the megadrought. In general, it's expected to contribute to dry regions becoming drier and wet regions becoming wetter, and although Chile has experienced drought periods before, none have been this bad or lasted so long. Warming global temperatures have changed the weather patterns that once brought precipitation, and models suggest those patterns are likely to persist.

That's bad news for central Chile, which relies on the mountain water towers in the Maipo River Basin for freshwater. According to a paper published in the journal *Nature* in 2019, water towers around the world, from the Andes to the Himalaya, are imperiled by climate change.

Two years ago, Perry and Matthews installed a weather station on Mount Everest, making it the world's highest. The Chile trek was the latest National Geographic Society expedition to explore and research climate and environmental changes in some of Earth's most fragile environments.

**IT TOOK THE TEAM ABOUT 10 DAYS TO SUMMIT** Tupungato, at more than 21,000 feet, and five days to descend. In the months before the trip, team members trained extensively. Perry spent hours climbing steep Appalachian trails in North Carolina with a heavy backpack. Southeast of Santiago, Casassa climbed the hills above his home.

**The National Geographic Society,** committed to illuminating and protecting the wonder of our world, funded Explorers Baker Perry, Gino Casassa, and Armando Vega's expedition to study one of the most vulnerable water towers in South America.

ILLUSTRATIONS BY JOE MCKENDRY

Team members began their trip at 6,152 feet in an ecosystem with shrubs and bushes dotting the landscape. That scene quickly changed as they climbed over the next few days. It was a challenge.

The team consisted of Perry, Casassa and his colleagues at the Chilean water ministry, mountain guides, and muleteers, who move pack mules and horses up mountains.

"The horses had gone a couple days before us to try to make sure the trail was open, and the snow was so deep that the horses were up to their necks," Perry says. Four riders on horseback plus mules carrying cargo advanced ahead of the team. Not only was the climb steep, but temperatures had warmed just enough that instead of being able to walk on the snow, the climbers fell through it. "At one point I took a step, and the next thing I knew I was up to my waist," says Perry.

The weather station the team carried up Tupungato is a 120-pound, six-foot-tall, collapsible tripod made of aluminum. It is light enough to carry in bits and pieces in multiple backpacks but should be strong enough to withstand some of the world's strongest winds. As the team struggled through the snow, Perry says, it became clear the horses would not be able to climb as high as the team had hoped. Casassa called in a helicopter to ferry the station the rest of the way up the mountain.

Securing the instrument near the summit required bolting the weather station's tripod to rock and staking it with guy wires to keep it stable. The station is powered by solar-charged batteries and has an antenna for satellite communication. It already has clocked wind speeds of over 116 miles an hour, Perry says.

The scientists also installed temperature sensors three feet deep in the permafrost near the summit to track temperature changes in the frozen soil. The station will measure radiation, snow depth, and albedo, or reflectivity. Albedo is important because as less snow falls and the ice melts, it exposes lower albedo snow and eventually dark rock, raising surrounding surface temperatures and potentially accelerating the melt.

"As the climate warms, glaciers will retreat quite quickly," Matthews says. "How quickly? We don't know. Most observations have been made on the mountain at quite low elevations, so we lack information about what's going on in the upper third."

Determining how much freshwater Chile has locked in its mountains and when it might reach critically low levels are complex predictions, Matthews says. In the short term, the heat that accelerates snow and ice melt leads to more water, which can cause floods. But as melting speeds up, the glaciers eventually "get so small that even though they're melting quite quickly, there's less to melt," and so there's less runoff, he says.

Scientists refer to that transition point as "peak water," when the short-term rush of water turns into a longer-term shortage.

Only two other high-altitude weather stations are located in the Maipo River Basin, and Casassa hopes the new station will become one of many he and his colleagues install throughout Chile.

As the United States and other countries,

Marcelino Ortega Martínez (front) and Fernando Ortega Ortega are muleteers—people experienced in moving equipment on mules—who served an essential role on the expedition. Here they ride horses next to mules loaded with equipment headed for the Baños Azules camp at 8,200 feet. Behind them is Bárbara Donoso, chef for the mountain guide team, followed by several guides. In the background is the snowy peak of Tupungato.

including Chile, commit to reducing the emissions that fuel climate change, central Chile nonetheless must prepare for worst-case scenarios.

Garreaud hesitates to say Santiago might hit a "day zero" for running out of water, as residents of Cape Town, South Africa, feared might happen there in 2018. He's optimistic that the region can adapt, using water more efficiently and cutting down on consumption.

Northwest of Santiago, a private company is building the first general-use desalination plant that could provide water for drinking, agriculture, and mining. It's one of many tools aimed at ensuring reliable freshwater for central Chile, says Sebastián Vicuña, a civil engineer at Chile's Catholic University who researches how the country can adapt to climate change.

Local water utility companies and municipalities are using tactics such as damming a tributary of the Maipo River to store water and trucking in drinking water for those whose wells have run dry.

Models by Vicuña and his colleagues found that the drought should continue into mid-century and reliable drinking water for Santiago will come at the expense of supplying water to farmers. For now, Vicuña says, the glaciers are receding, but "they are still a very reliable supply of water every year, especially during the drought." If the glaciers do eventually disappear, as is expected, that reserve of water will go with them. □

**Sarah Gibbens** is a staff writer for *National Geographic*. Photographer **Armando Vega** covers cultural and environmental topics.

# AFGHANISTAN'S

**LEFT**
Sumbul Rhea, 17, a student at Afghanistan's National Institute of Music, is from a remote village in Nuristan. Her father was kidnapped and ransomed three times by the Taliban, she says, for letting his daughters study music.

**RIGHT**
Samiullah, 16, a Taliban recruit accused of planting a bomb targeting Afghan troops, is in a juvenile rehabilitation center in Faizabad. His father, who commands an anti-Taliban militia, refused to sign papers for his son's release.

# DANGEROUS DIVIDE

After U.S. troops exit, which Afghanistan will prevail—one that defends **FREEDOMS** gained since 2001 or one that reverts to **OPPRESSION** by the Taliban?

BY **JASON MOTLAGH**
PHOTOGRAPHS BY **KIANA HAYERI**

Kote Sangi bazaar in western Kabul hums with early morning activity in April, during the Islamic holy month of Ramadan. Most of Afghanistan’s 39 million people are Sunni Muslims. Minority Shiites are often targeted by Sunni militants.

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After four weeks at remote frontline positions in Badakhshan Province, off-duty Afghan soldiers trek five hours to reach the provincial capital, Faizabad. The Taliban took the area in early July, killing and capturing many soldiers and allied militiamen.

# In the blue haze of hookah smoke that fills Kandahar's Cafe Delight on a weekend afternoon, it's easy to forget there's a war outside.

In a suburban development on the outskirts of Kandahar, Cafe Delight entertains businessmen, officials, and boys with risqué music videos and sports, often past midnight. Women aren't barred, but only a few have come in the two years since it opened. Under the Taliban, music and TV were banned and women couldn't leave home without a male relative.

**YOUNG MALE PROFESSIONALS** with well-groomed beards and mullet cuts slump in plush chairs sipping espresso drinks beneath flat-screens that pulse with racy Turkish and Indian music videos, the bare midriffs of women blurred by channel censors.

This is still Afghanistan, a conservative Islamic society. But the patrons belong to a more permissive, urbane generation that's come of age since the fall of the Taliban, with vague to no memory of the oppressive, fundamentalist regime, born in this southern city, that banned television, music, and cinema; forbade men from trimming their beards; and forced women to wear head-to-toe burkas.

Café owner Ahmadullah Akbari returned from two years in cosmopolitan Dubai in 2018 to start his business in Ayno Maina, a sprawling modern development on the outskirts of Kandahar. With eucalyptus-lined streets, luxury villas, and shopping plazas lit by nearly round-the-clock electricity, the gated enclave offers an atmosphere of suburban normalcy for middle- and upper-class Afghans, many on a government payroll. “We have no worries here,” says Suleiman Aryan, 28, an English teacher who works and lives in the complex with his wife and two children.

But beyond the jagged mountains to the north, a storm has gathered. Emboldened by a February 2020 agreement with the United States that sidelined the Afghan government and paved the way for the withdrawal of American forces, the Taliban tightened their grip on rural areas and are closing in on cities at breathtaking speed. Behind the café counter, Akbari monitors closed-circuit TV cameras he recently installed to thwart “sticky bombs”—crude explosives triggered by mobile phones—that are targeting officials, activists, minorities, and journalists, as well as random civilians, part of the extremists’ strategy to eliminate dissent and project fear deep into urban centers.

Twenty years have elapsed since the U.S. invaded Afghanistan to rout the al Qaeda terrorists behind the September 11 attacks and toppled

the Afghan Taliban regime that sheltered them. Taliban leaders took refuge in neighboring Pakistan, and when Washington's attention swung to war in Iraq, they mounted a comeback. An infusion of military and development funds to the post-Taliban government followed, mostly from the U.S., totaling more than 150,000 international troops and nearly seven billion dollars in annual aid at the height in 2011. But the surge failed to quash the Taliban, and the U.S. eventually decided to end its longest modern war.

With the last U.S. forces set to withdraw before September 11 of this year, Taliban militants contest or control at least 80 percent of local districts across the country's 34 provinces. U.S. and Pakistani officials privately say they fear the extremists could retake the nation within six months to two years. More than three in four Afghans today are under 25: too young to remember the Taliban's reign of fear and, especially in urban centers, too accustomed to freedoms to be willing to relinquish them. Some in rural areas see the fundamentalists' return as inevitable and preferable, but many Afghans shaped by the post-2001 reality are defiant, unwilling to revert to a reactionary and repressive past.

**LESS THAN FIVE MILES** outside Kandahar, the Arghandab River has become a front line. On a clear morning in March, an Afghan Air Force

Officer Abdul Ghafoor, 22, stands guard in Panjwai district, a strategic spot on a road to the provincial capital of Kandahar, the birthplace of the Taliban that the militants are fighting to reclaim. Ghafoor dreamed of studying medicine but took a risky job with the police for $165 a month. He says he wasn't paid for half a year and had to delay his wedding. From his lonely outpost, he has seen the Taliban getting ever closer.

A-29 aircraft wheels and dive-bombs a mud-brick target on the Taliban-held side, sending a rumble through the valley. The militants respond with erratic rocket fire of the kind that has killed civilians and turned a nearby market into a ghost town.

"Rockets and shells are launched blindly every day," says Hayatullah, a farmer who like many Afghans uses just one name. He fled his village months ago with only the clothes on his back, and lives in one room with his wife and nine children. Like thousands of displaced families in the south, they await government aid that hasn't come. "The fighting has destroyed our homes and crops, and we are not safe here," he adds, flinching at the sound of artillery fire from a former U.S. base now used by the Afghan Army.

In summer, the river valley that gives its name to the surrounding district becomes a dense maze of lush fruit orchards, canals, and earthen walls that gave militants cover to ambush American soldiers here a decade ago. Security later improved, allowing farmers to harvest the grapes and pomegranates for which the valley is famous. But locals say the relative calm was undone by rampant graft, tribal favoritism, and predatory policing that alienated a population bereft of basic services. Twenty-five years ago, discontent with corrupt warlords helped enable the Taliban's rise to power. Today similar abuse is fueling the group's resurgence.

A few years ago, "Arghandab was the most secure district in the region," laments Shah Mohammad Ahmadi, a former district governor. "The U.S. did what they should have done; there were many good projects here. Unfortunately, some of our corrupted officials have betrayed our country and fed only themselves. When people are not heard by the government, they seek help from others such as the Taliban."

Haji Adam, a tribal elder on the Taliban-controlled side of the river, says, "For 20 years the whole world came and money poured in, but how did it help us? If the water was in our control ... if there was electricity, we would have products instead of war. If the roads were paved, there would not be so much destruction." Instead, "nothing significant has been built" in Kandahar since the Taliban were ousted in 2001, he says. The region's only large-scale hospital, he notes, was built by the Chinese in the 1970s.

These days, Mirwais Hospital, known as the Chinese hospital, is packed with casualties. A pair of police officers shot on patrol lie on gurneys, dead on arrival. In intensive care, three men recover from a roadside bomb blast. Down the hall, 16-year-old Lalai is in critical condition from a stray bullet fired in a Taliban-ruled district six hours' drive away. Relatives brought him to Kandahar after two failed surgeries at a local clinic.

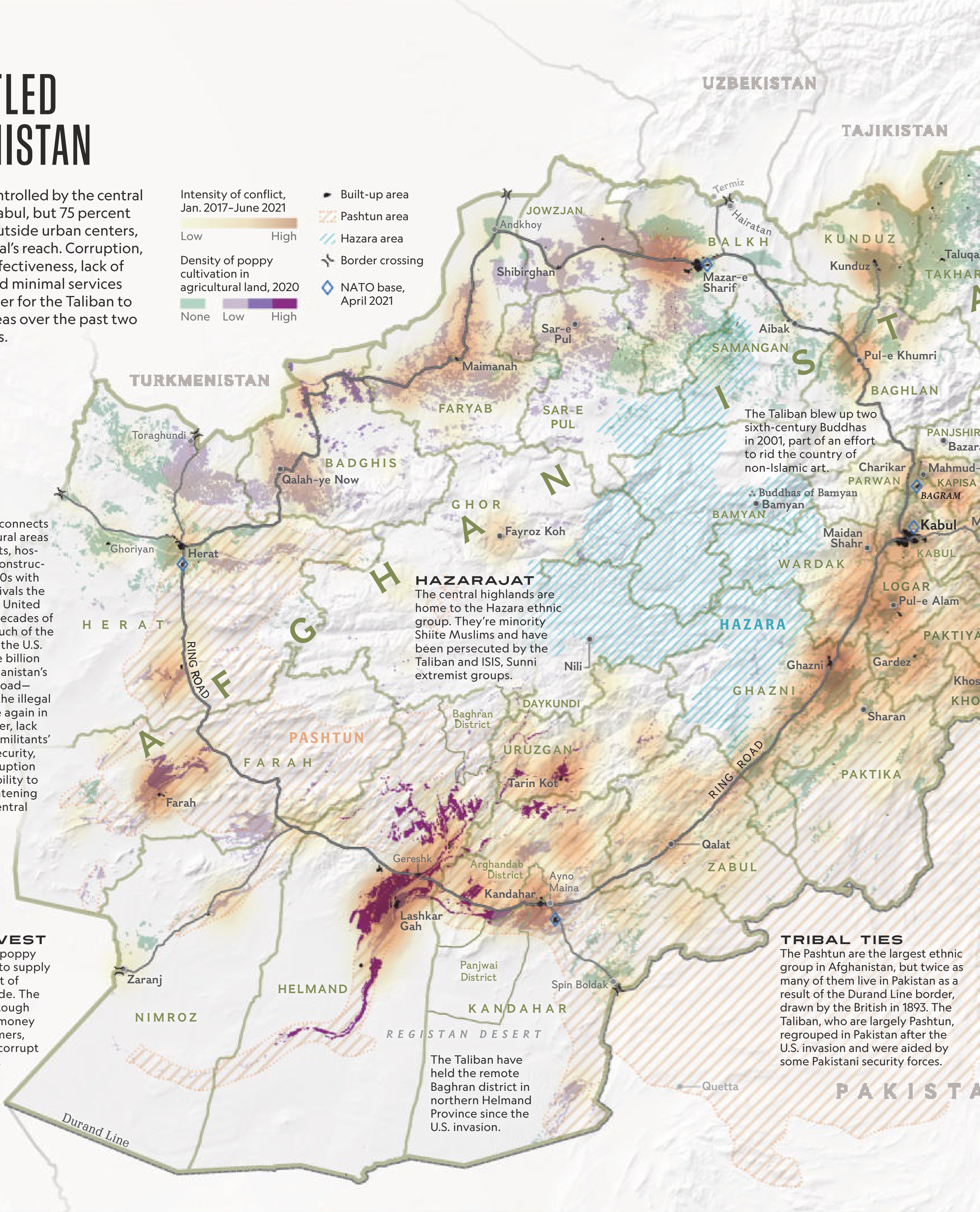
"He's an orphan," whispers his uncle. "His parents are gone, and his older brother was killed three months ago." After a month of care, Lalai was getting worse. Ten days later, he died.

**AFGHANISTAN'S URBAN-RURAL DIVIDE** has only widened in the past 20 years, and ruling classes ignore it at their peril. Since the late 19th century,

Hafiza gazes out the window of the small home near Faizabad where she took refuge after the Taliban seized her village in 2019. When one of her four sons joined the Taliban, Hafiza begged his commander to let him come home. “You’ve given two sons to the government and one to [anti-Taliban] militia,” she says he replied. “This one will be ours.”

# EMBATTLED AFGHANISTAN

The country is controlled by the central government in Kabul, but 75 percent of Afghans live outside urban centers, far from the capital's reach. Corruption, government ineffectiveness, lack of infrastructure, and minimal services have made it easier for the Taliban to recruit in rural areas over the past two troubled decades.



Intensity of conflict, Jan. 2017–June 2021

Low High

Density of poppy cultivation in agricultural land, 2020

None Low High

- Built-up area
- Pashtun area
- Hazara area
- Border crossing
- NATO base, April 2021

**RING ROAD**
This 1,400-mile road connects cities and provides rural areas with access to markets, hospitals, and schools. Construction began in the 1950s with help from Cold War rivals the Soviet Union and the United States; subsequent decades of conflict destroyed much of the highway. Since 2002, the U.S. has spent some three billion dollars building Afghanistan's roads, but the Ring Road—also a key artery for the illegal poppy trade—is once again in disrepair from weather, lack of maintenance, and militants' roadside bombs. Insecurity, inefficiency, and corruption limit Afghanistan's ability to maintain roads, threatening the viability of the central government.

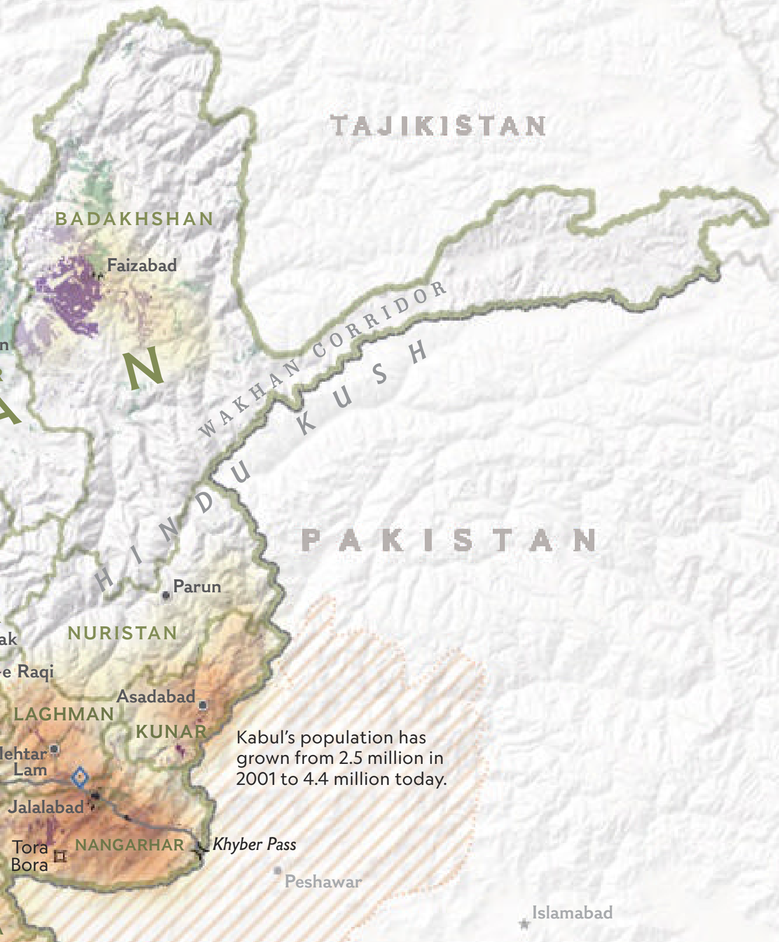
**OPIUM HARVEST**
Afghanistan's opium poppy harvest is estimated to supply more than 80 percent of the global heroin trade. The hardy crop grows in tough conditions and puts money in the pockets of farmers, Taliban leaders, and corrupt government officials.

The Taliban blew up two sixth-century Buddhas in 2001, part of an effort to rid the country of non-Islamic art.

**HAZARAJAT**
The central highlands are home to the Hazara ethnic group. They're minority Shiite Muslims and have been persecuted by the Taliban and ISIS, Sunni extremist groups.

The Taliban have held the remote Baghran district in northern Helmand Province since the U.S. invasion.

**TRIBAL TIES**
The Pashtun are the largest ethnic group in Afghanistan, but twice as many of them live in Pakistan as a result of the Durand Line border, drawn by the British in 1893. The Taliban, who are largely Pashtun, regrouped in Pakistan after the U.S. invasion and were aided by some Pakistani security forces.

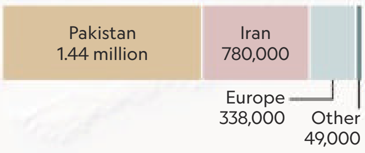


Kabul's population has grown from 2.5 million in 2001 to 4.4 million today.

## WHERE AFGHANS FLEE

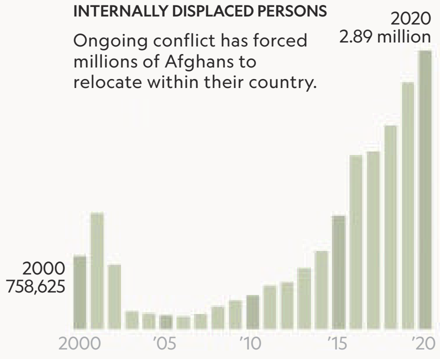
Other nations harbored 2.6 million registered refugees from Afghanistan in 2020. Globally, the country accounts for the third largest refugee population, after Syria and Venezuela. Increasing violence continues to drive people out of the country.

**AFGHAN REFUGEES (2020)**



**INTERNALLY DISPLACED PERSONS**

Ongoing conflict has forced millions of Afghans to relocate within their country.



# FIGHTING FOR CONTROL

The Taliban arose out of a civil war in the 1990s, after the Soviets were driven out. The Islamic militant group seized control of Kandahar in 1994 and the central government in Kabul in 1996, ruling most of Afghanistan until the U.S. invaded in 2001. They're now retaking control of many areas, using rural footholds to advance on cities as the U.S. withdraws.

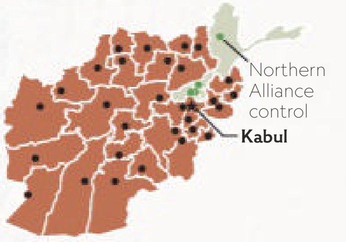
**Control of provincial capital**
- ● Taliban
- ● Under threat by Taliban
- ● Government of Afghanistan or Northern Alliance

**Taliban influence in province**
- ▇ Control
- ▇ High
- ▇ Moderate
- ▇ Minimal
- ▇ None or insignificant

## PRE-9/11

**2000 *(shown on map)***

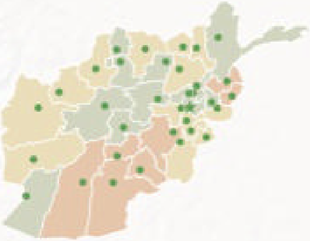
The Taliban control most provinces and their capitals. The Northern Alliance controls 10 percent of Afghanistan in the mountainous northeast.



## POST-U.S. INVASION

**2002**

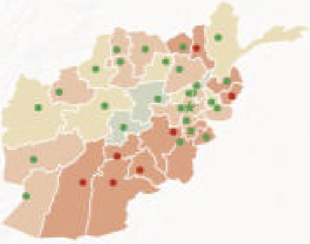
The U.S. ejects the Taliban from Kabul and all provincial capitals. Leaders flee to Pakistan. Two years later a new constitution is adopted and a government elected.



## PRE-U.S. TROOP SURGE

**2009**

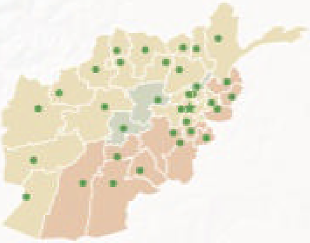
A years-long Taliban resurgence gains ground as the group seizes control of several districts and threatens to overtake many provincial capitals.



## POST-SURGE

**2012**

After a two-year surge in U.S. forces, NATO wrests control of most areas from the Taliban, pushing them back to their rural strongholds.

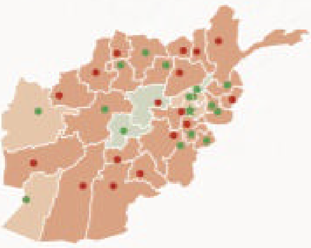


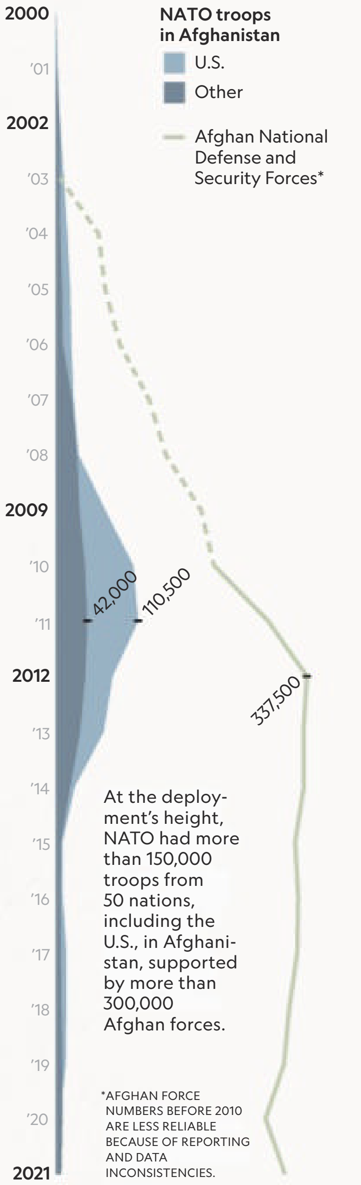
## WITHDRAWAL

**2021**

***(map data as of July 1, 2021)***

The Taliban regain large areas after NATO turns primary security over to the Afghan military in 2014. The U.S. pledges a full withdrawal by September 11, 2021.





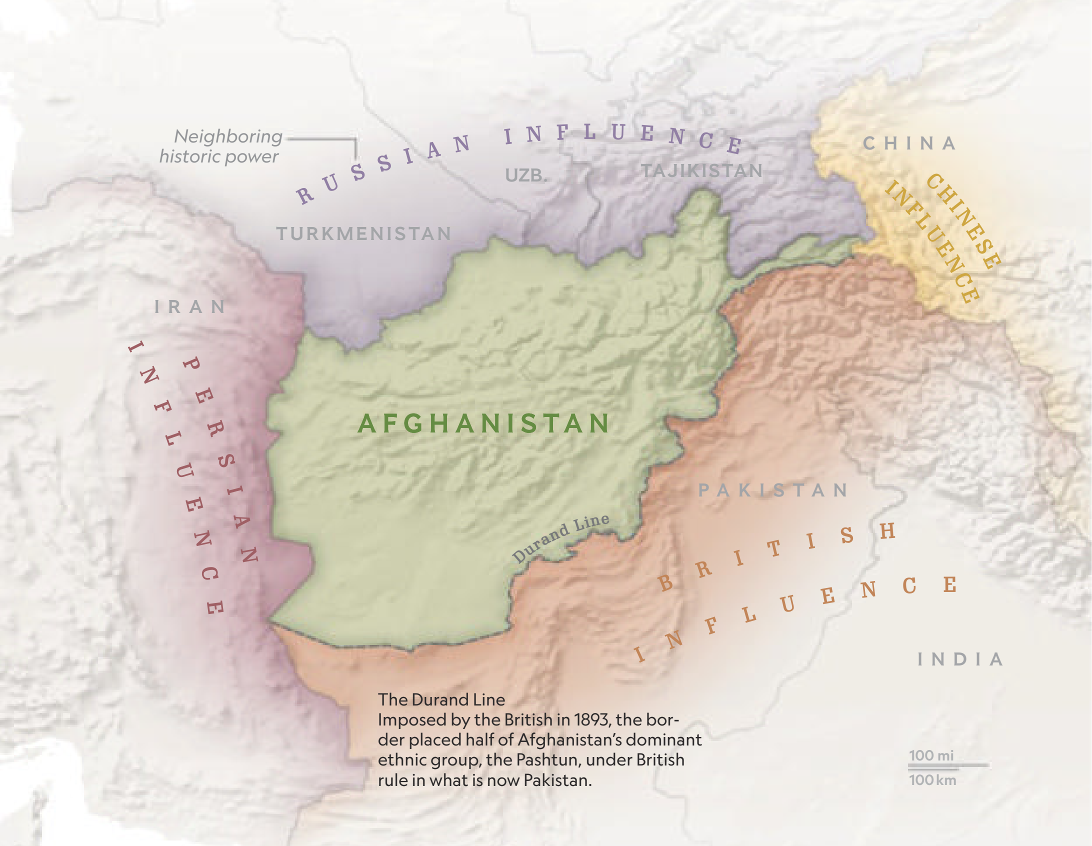
At the deployment's height, NATO had more than 150,000 troops from 50 nations, including the U.S., in Afghanistan, supported by more than 300,000 Afghan forces.

*AFGHAN FORCE NUMBERS BEFORE 2010 ARE LESS RELIABLE BECAUSE OF REPORTING AND DATA INCONSISTENCIES.

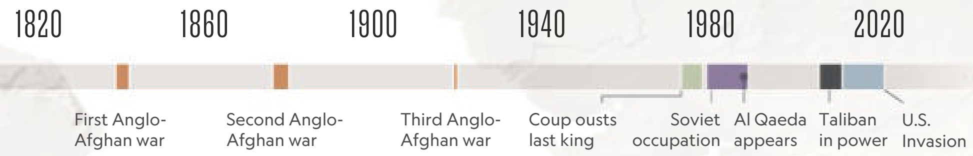
CHRISTINE FELLENZ, THEODORE SICKLEY, NGM STAFF; LAWSON PARKER. SOURCES: AFGHANISTAN INFORMATION MANAGEMENT SERVICES; ARMED CONFLICT LOCATION & EVENT DATA PROJECT; FRED KAGAN, CRITICAL THREATS PROJECT; ELI BERMAN, JACOB SHAPIRO, EMPIRICAL STUDIES OF CONFLICT; BILL ROGGIO, FOUNDATION FOR DEFENSE OF DEMOCRACIES; AFGHANISTAN 2012 LAND COVER DATABASE, FAO; NATO; SPECIAL INSPECTOR GENERAL FOR AFGHANISTAN RECONSTRUCTION; UNHCR; UNODC; WFP

# CENTURIES OF STRIFE

**LANDLOCKED AND SURROUNDED** by mountains, deserts, and competing empires, this central Asian nation has been shaped by war and diplomacy since the Afghan Empire was founded in 1747. A century later, geopolitical rivalries between British interests in India to the east and Russian expansion from the north helped influence its present boundaries. Afghanistan's national identity also has been molded in its modern history by resistance to foreign incursions, nearly all of them by non-Muslim powers.



The Durand Line
Imposed by the British in 1893, the border placed half of Afghanistan's dominant ethnic group, the Pashtun, under British rule in what is now Pakistan.



**Royal rule (1747-1978)**
Afghanistan is led by monarchs, most of them from the Pashtun ethnic group that dominates today's Taliban.

**Anglo-Afghan wars**
Britain tries to annex Afghanistan three times to curb Russian expansion and protect British rule over India.

**Soviet-Afghan war**
The U.S.S.R. invades to prop up an unpopular communist government. Islamic guerrilla resistance arises.

**U.S.-led invasion**
The Taliban regime is ousted for sheltering al Qaeda and Osama bin Laden after the 9/11 attacks in the U.S.

# THE COST OF CONFLICT

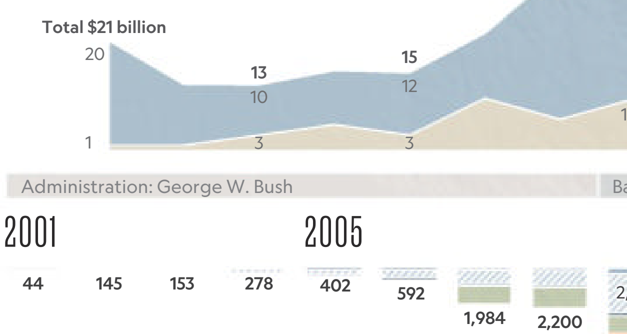
The U.S. government reports the war in Afghanistan has cost taxpayers nearly a trillion dollars, but a Costs of War Project estimate, which includes the cost of health care for veterans and interest on war-related borrowing, is twice that.

## BUDGET BREAKDOWN

Department of Defense war operations make up most of the spending, with about 15 percent allocated for reconstruction efforts.

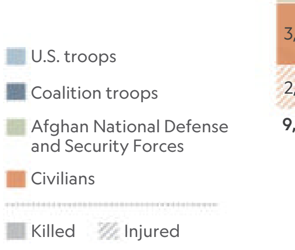
▨ War ($734 billion)
▨ Reconstruction ($130 billion)

War budgets shown here begin in October 2001, when the U.S. invaded Afghanistan, and run through September 30, 2020. Full-year 2021 data is not yet available.



## HUMAN TOLL

Afghanistan suffered more than 3,000 civilian deaths from armed conflict in each of the last seven years. In 2020, 43 percent of the dead were women and children. In the last two years, about 30 to 40 Afghan forces were killed daily. Taliban and other opposition deaths are estimated at more than 50,000 since the war began.



DATA FOR CIVILIANS STARTS IN 2009, FOR AFGHAN FORCES IN 2007. AFGHAN FORCES' CASUALTIES, CLAS
AS OF 2017, ARE NOT AVAILABLE TO THE PUBLIC AND ARE ESTIMATES. SOURCES: SPECIAL INSPECTOR GEN
AFGHANISTAN RECONSTRUCTION; DOD; WORLD BANK; COSTS OF WAR PROJECT, BROWN UNIVERSITY; U

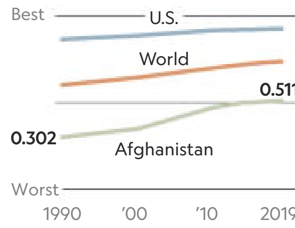
## SLOW PROGRESS

Afghanistan is one of the world's poorest countries but is seeing some advances. Access to health care and education has increased in the past 20 years, especially for girls. But conflict continues to drive displacement, poverty, and hunger.

MONICA SERRANO, CHRISTINE FELLENZ, MATTHEW W. CHWASTYK, NGM STAFF; LAWSON PARKER

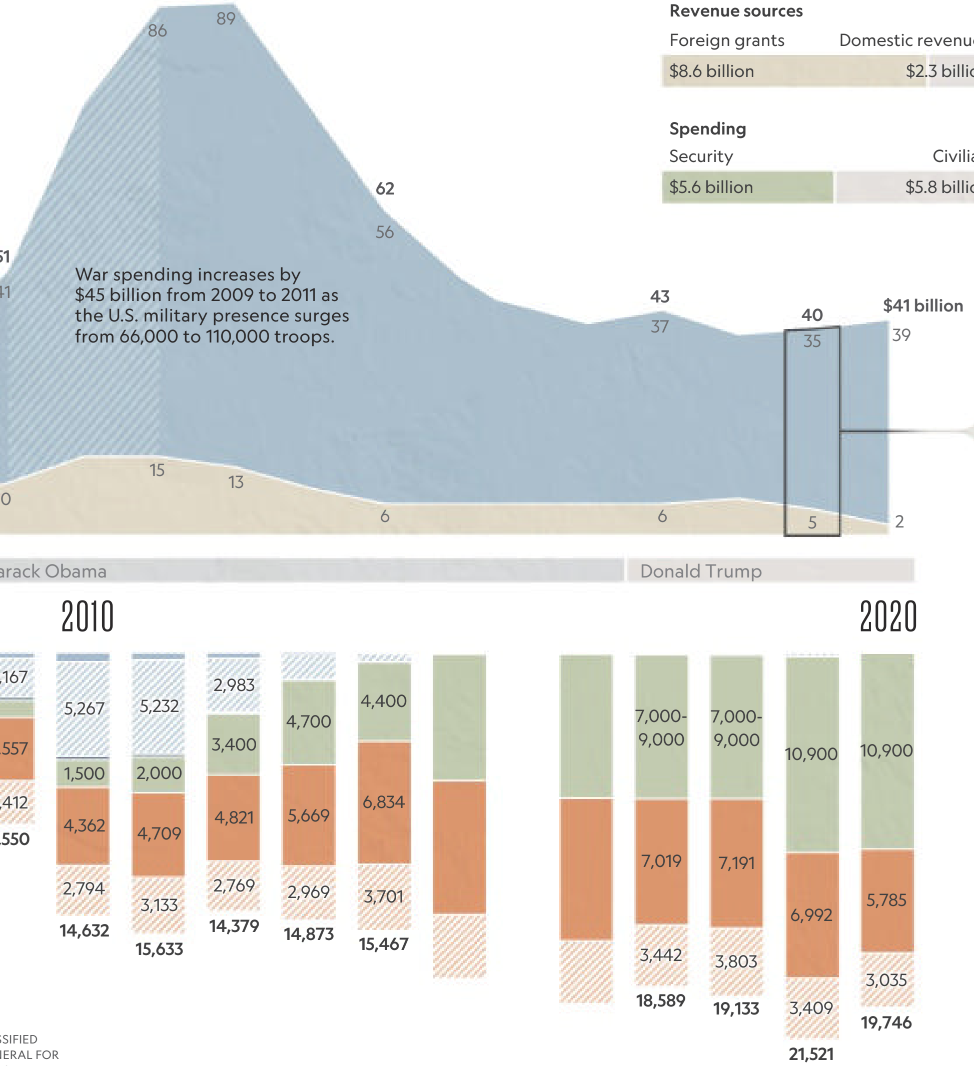
### STANDARD OF LIVING

The country has improved on this ove
measure of income, health, and educa



SOURCE: UNITED NATIONS DEVELOPMENT PROGRAMME HUMAN DEVELOPMENT INDEX

Al Qaeda founder Osama bin Laden is killed in Abbottabad, Pakistan, in May 2011.



War spending increases by $45 billion from 2009 to 2011 as the U.S. military presence surges from 66,000 to 110,000 troops.

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## DEPENDENT ON AID

Afghanistan relies on international funding for three-quarters of its total public expenditures—costs that are largely driven by security spending.

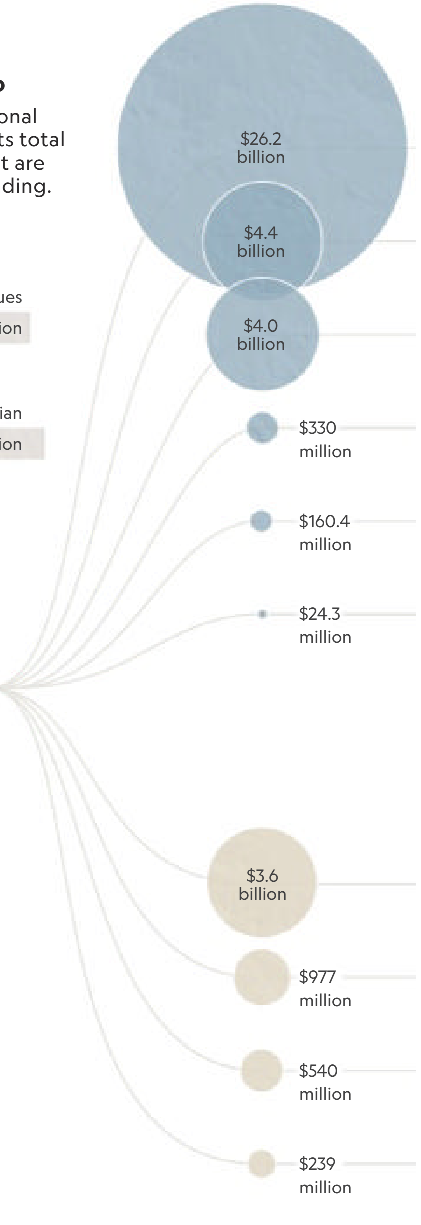
**TOTAL PUBLIC EXPENDITURE**

**Revenue sources**

| Foreign grants | Domestic revenues |
|---|---|
| $8.6 billion | $2.3 billion |

**Spending**

| Security | Civilian |
|---|---|
| $5.6 billion | $5.8 billion |



## WAR COST, 2019
### $35 BILLION

**Operation and maintenance**
Personnel, training, transportation, and electronic equipment

**Procurement**
Major equipment such as aircraft, ships, and armored vehicles

**Military personnel**
Salaries and compensation for active and retired military

**Research and development**
Testing of equipment and supplies, such as computer software

**Revolving funds**
Miscellaneous goods and services

**Military construction**
Large projects such as bases, schools, and medical clinics

## RECONSTRUCTION COST, 2019
### $5 BILLION

**Security**
Support for Afghan National Security Forces and counter-narcotics

**Agency operations**
Diplomacy and development programs

**Governance and development**
Economy, education, counterterrorism, and narcotics control

**Humanitarian**
Disaster assistance for the internally displaced and for refugees

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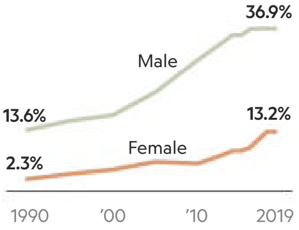
tion.

**SECONDARY EDUCATION**

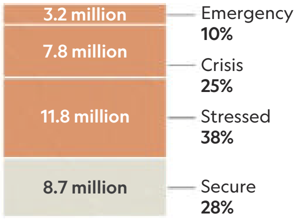
Only a small portion of Afghans 25 and older have attended secondary school.



SOURCES: UNESCO; BARRO AND LEE

**FOOD INSECURITY**

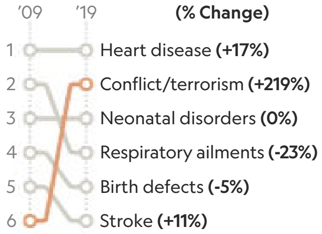
Nearly three-quarters of the population lacks access to enough food.



SOURCE: INTEGRATED FOOD SECURITY PHASE CLASSIFICATION

**CAUSE OF DEATH**

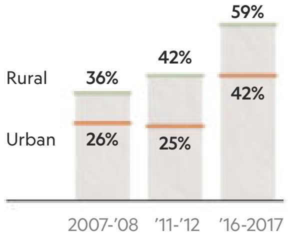
Violent conflict dramatically rises as a leading cause of death.



SOURCE: INSTITUTE FOR HEALTH METRICS AND EVALUATION

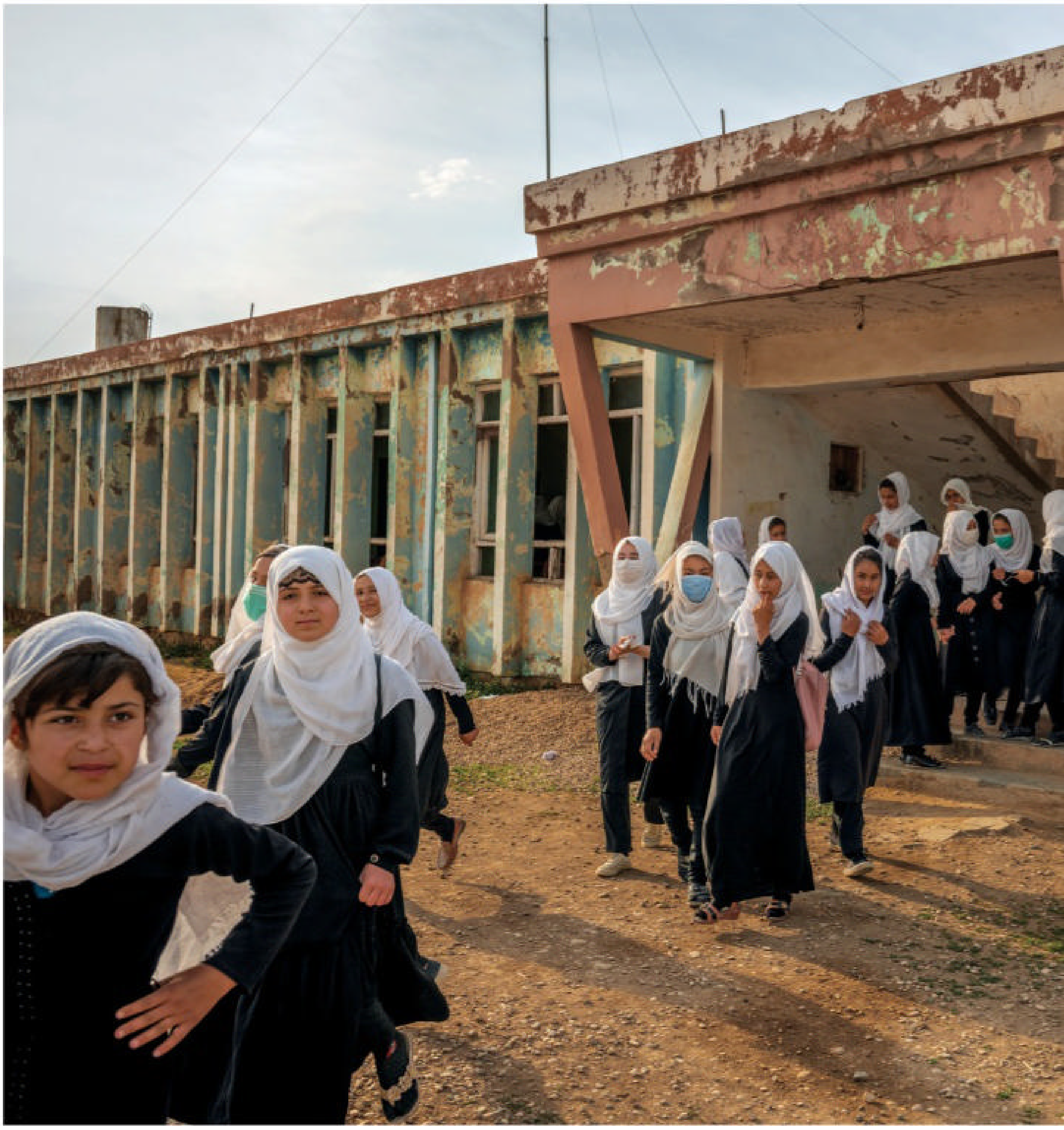
**POVERTY**

A large percentage of Afghans live below the poverty line.



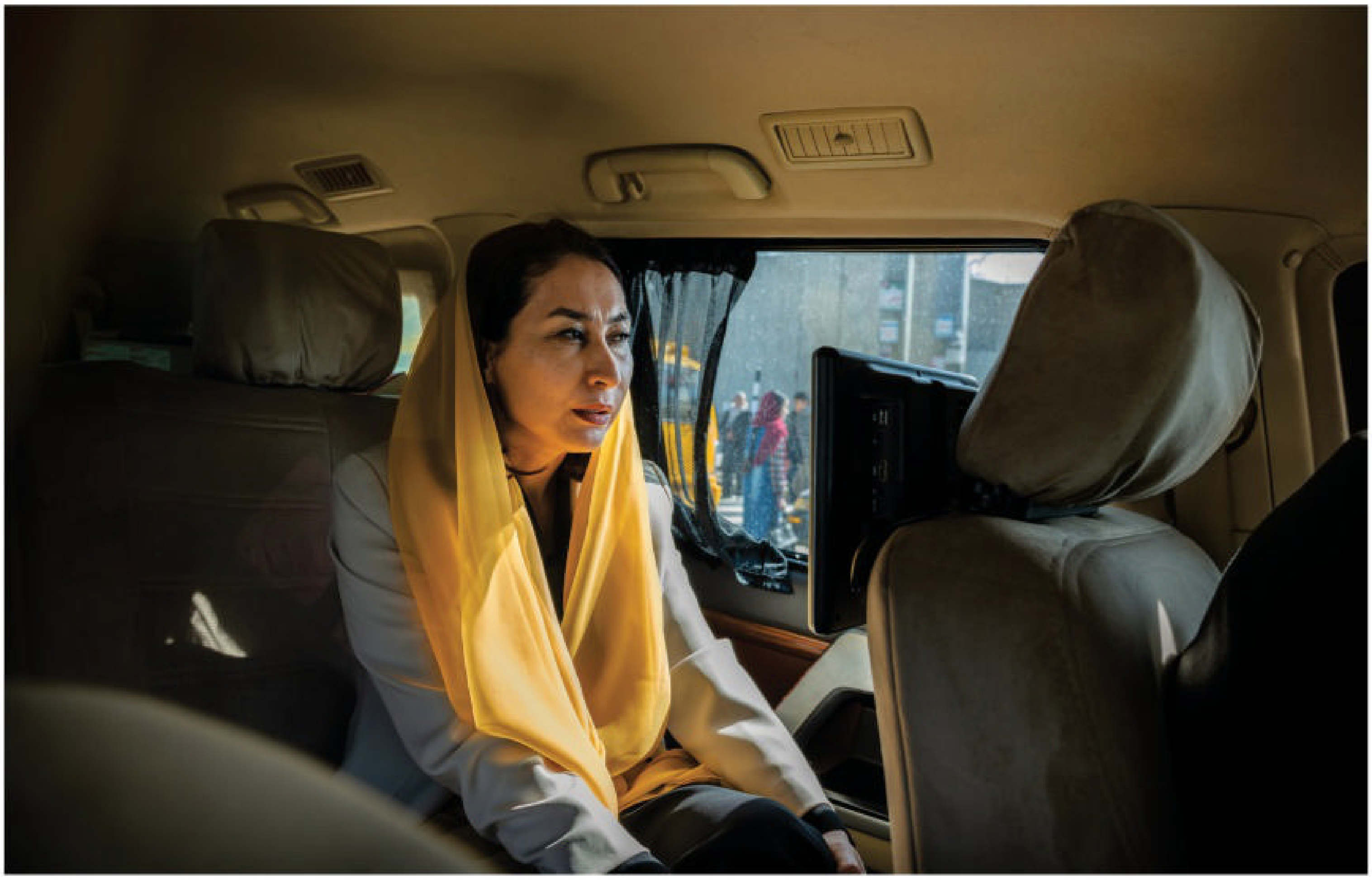
SOURCE: ISLAMIC REPUBLIC OF AFGHANISTAN CENTRAL STATISTICS ORGANIZATION

Ethnic minority Uzbek girls emerge from Marshal Dostum High School in the northwestern city of Shibirghan, Jowzjan Province. The families of more than two dozen students relocated to the provincial capital after the Taliban seized the province's southern districts and banned girls' education again in 2018.



**BELOW**

Member of Parliament Raihana Azad rides through the streets of Kabul in a bulletproof SUV en route to a legislative session on International Women's Day. The outspoken 38-year-old survived an assassination attempt and a suicide bombing. She moved her children overseas and fears she may have to follow if the Taliban return to power.



"we have had at least a dozen cycles of rural elites who came and captured power in Kabul, became rulers, and then eventually became almost alien to their former bases," says Tamim Asey, a former deputy minister of defense and founder of the Institute of War and Peace Studies, a Kabul-based think tank. It's a "war of two worldviews and systems of values. On one side are people in major cities who are more liberal, moderate, and educated but have grown out of touch with the rural population. On the other are conservative, rural Afghans who feel neglected by a centralized state run by elites."

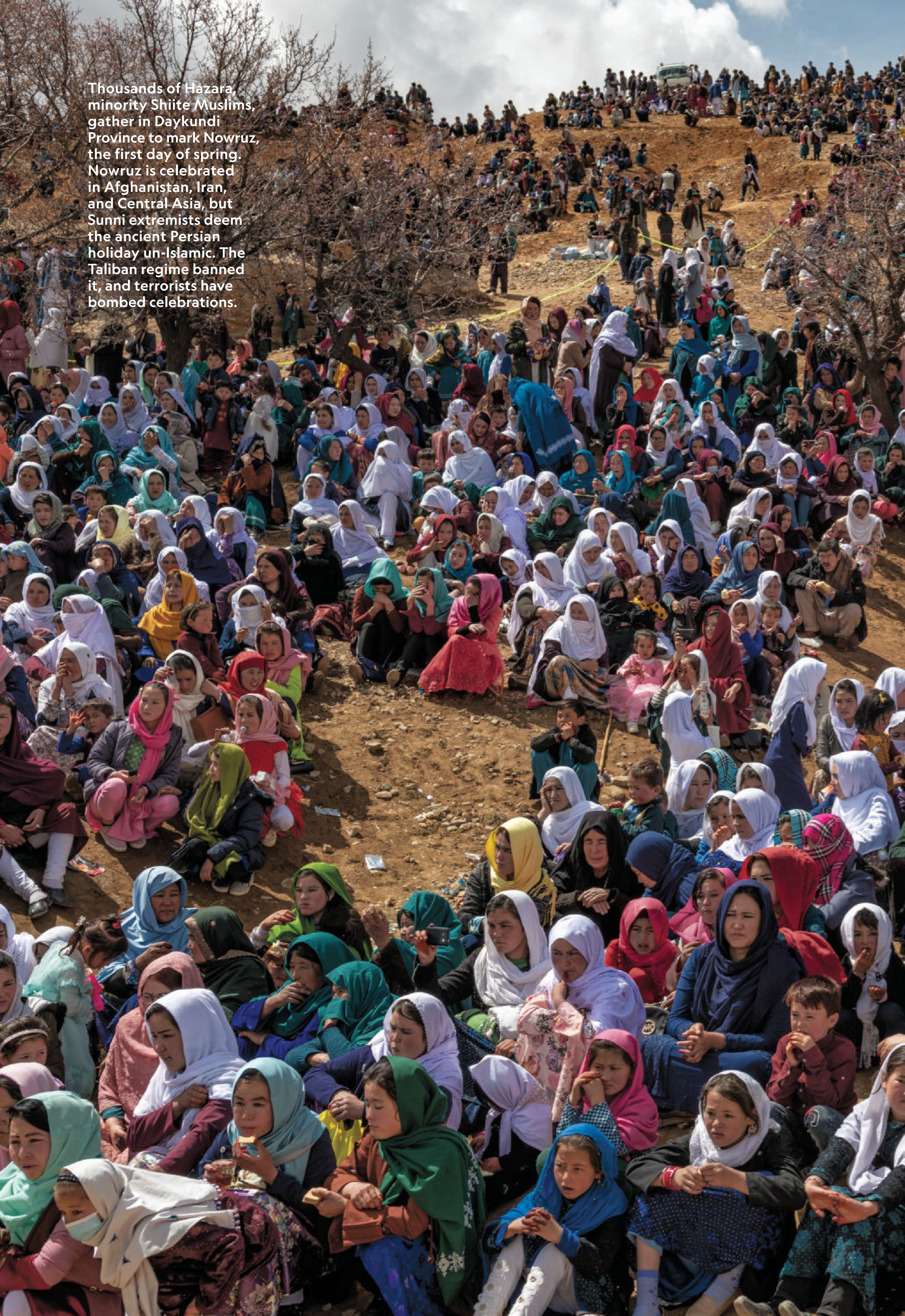
For 50 years, Afghanistan has swung from coups to conflicts. In 1973 an Afghan general ousted the king and declared himself president. Five years later, Afghan communists assassinated him and seized power. The Soviet Union invaded the next year to prop up the unpopular communists, sparking a decade-long guerrilla war. The U.S. funneled billions of dollars via Pakistan to anti-Soviet mujahideen fighters from across the Islamic world—including the Saudi jihadist Osama bin Laden—and they eventually forced the Soviets to withdraw. A power-sharing deal failed, and the militants fractured into warring factions. The Taliban emerged in the chaos and seized power in 1996.

The Taliban soon grabbed headlines for ruthlessly enforcing an eye-for-an-eye brand of sharia law, brutally oppressing women and minorities, destroying cultural treasures, and sheltering al Qaeda. After 9/11, the U.S. invaded to root out those behind the attacks, but another, less clearly defined mission took shape. U.S. and NATO leaders hoped economic opportunity and democracy would inoculate the country against becoming a terrorist haven again.

Education, political participation, and the status of women improved, but a deluge of foreign money exacerbated urban-rural fault lines. Aid and military contracts stoked a bubble economy in cities. But most Afghans still scrape by on subsistence agriculture, despite the $144 billion-plus that the U.S. has invested in reconstruction since 2001—far more, even in inflation-adjusted dollars, than it contributed to rebuilding Western Europe after World War II.

Keenly aware of the disparities, Afghanistan's first elected president, Hamid Karzai, launched ambitious rural development programs. Led by then finance minister Ashraf Ghani, a former World Bank official who is now the country's president, the central government directed almost three billion dollars from international donors to self-governed community councils to fund local priorities and loans. Donors spent billions on road construction to connect villages to markets. The oft-repeated mantra justified the investment: Where the road ends, the Taliban begin. (Ironically, better roads have helped militants and opium traders extend their reach too.)

"Access to roads, modern education, health care, electricity—all of that was going to help stabilize the country," says Richard Boucher, the top U.S. diplomat for South and Central Asia from 2006 to 2009. The theory was good, but the implementation, he says, was flawed. "We should have put more effort into training the class of Afghan technocrats, the people who administer programs, who could account for money



Thousands of Hazara, minority Shiite Muslims, gather in Daykundi Province to mark Nowruz, the first day of spring. Nowruz is celebrated in Afghanistan, Iran, and Central Asia, but Sunni extremists deem the ancient Persian holiday un-Islamic. The Taliban regime banned it, and terrorists have bombed celebrations.

and could carry out government policies ... We were spending a lot of money on ourselves and our contractors, and not so much on the people of Afghanistan."

Reconstruction and security contracts were controlled by warlords and elites who fed patronage networks along ethnic, tribal, and family lines. According to Integrity Watch Afghanistan, an anti-corruption nonprofit, nearly all major contracts still go to people with close ties to officials. "By now we should have institutions," says Rahmatullah Amiri, a security analyst from Kandahar. "Instead we have individuals."

An October 2020 report by the U.S. inspector general for reconstruction in Afghanistan found that of $63 billion in reconstruction funds reviewed, nearly a third, roughly $19 billion, was "lost to waste, fraud, and abuse." Some of that money is flaunted in the capital, Kabul, where so-called overnight millionaires shuttle between high-rise towers and fortress compounds in armored Lexus SUVs, trailed by convoys of gunmen. Some made fortunes in new industries after 2001, but untold millions in cash have been whisked away to Dubai by officials and cronies, stashed in bank accounts and luxury condominiums.

A top-down culture of corruption fueled by foreign money has had an exceptionally damaging effect on police. "If a police station needs 15 officers, there are only three; the rest of the money is stolen," says Ahmadi, the former district governor in Kandahar Province.

Poorly equipped, police are also widely loathed for shaking people down to make up for unpaid salaries and scarce supplies. "The Taliban don't provide any services, and they don't build houses or clinics, but they do not steal," asserts Abdullah Jan, an unemployed farmer who fled Arghandab, echoing a common refrain among rural Afghans.

**ARMED WITH** the right connections, Mahmood Karzai left behind a string of Afghan restaurants in the U.S. and returned home to stake his claim to the post-2001 construction boom. An older brother of then President Hamid Karzai, he became the driving force behind Ayno Maina, one of Afghanistan's most successful private developments.

"I always took the risk. If I had a million, I'd gamble it in Las Vegas," says Mahmood, holding court beneath a crystal chandelier in his Italianate headquarters in the heart of the complex. An oil portrait of another Karzai brother, Ahmed Wali, hangs by the door. Until his 2011 assassination, Ahmed Wali was head of Kandahar's provincial council, the most powerful man in southern Afghanistan and a symbol of a flawed U.S. mission. He was a businessman and political enforcer, allegedly on the CIA's payroll, believed to have used his position and ties to cover drug trafficking and money laundering on a grand scale.

> 'On one side are **PEOPLE IN MAJOR CITIES** who are more liberal, moderate, and educated but have grown **OUT OF TOUCH** with the rural population.'

Mahmood's rise likewise was shadowed by allegations of foul play, notably a 2010 scandal at Kabul Bank, then the country's largest private bank, in which he was the third largest shareholder. Rumors the bank was failing sparked a run that nearly caused its collapse. An independent investigation found about $900 million had been stolen from the bank, 8 percent of the country's $12 billion GDP at the time. A U.S. grand jury investigated Mahmood over allegations of racketeering and tax evasion on a property sale in Dubai but never charged him.

Mahmood dismisses the allegations as smears by Karzai family enemies, but he acknowledges his proximity to power helped him. When his brother was president, the governor of Kandahar deeded him the land for Ayno Maina. Mahmood says he started with $50,000 of his own savings and secured a three-million-dollar loan from a U.S. government agency. "Wealth came and was consumed by a few, and I'm one of them," he says unapologetically. "Unfortunately, most Afghans did not get their proper share. We paid too much attention to urban development and forgot rural areas. And rural areas, they have the guns."

Last year President Ghani named Mahmood minister of urban and rural development. He has vowed to make homeownership more accessible to an urban population growing rapidly because of a high birth rate and grim economic prospects and insecurity in rural areas. Mahmood is expanding affordable housing at Ayno Maina and breaking ground on a bigger project in Kabul: a 12,500-acre, government-funded development featuring U.S.-style residential communities. "The demand is unbelievable," he says, with the zeal of a salesman. "If I sell everything, I will be so rich." Even so, he admits, "I'm not sure about the future of the country." When the U.S. leaves, he expects the Taliban "will take the country by force." If civil war breaks out, he says, he will leave. "I don't want to be killed."

**SEATED IN THE LOUNGE** of the five-star Serena Hotel in Kabul, Raihana Azad, 38, exudes the swagger of the capital's moneyed elite. A member of parliament since 2010, she wears a svelte black business suit without a headscarf, and speaks in a rapid-fire patter that fills the room.

An ethnic Hazara born in a hardscrabble pocket of Daykundi Province, she bore two children after an arranged marriage at 13. The story could have ended there, as it has for countless Afghan women, but Azad stayed in school, got a job with the UN promoting girls' education, and made it to Kabul, where she earned a law degree. She used her education to break taboos, suing for a divorce that made her an outcast in her own family. She ran for parliament and was elected to back-to-back terms, despite making no secret of her atheism or divorce. "People do not care about my personal life because I work for them and always tell them the truth," she says with a shrug.

Azad's brazen style has made her enemies. She survived a suicide bombing and an assassination attempt on a post-campaign trip to the countryside. Death threats forced her to move her children abroad, change locations frequently, and travel in a bulletproof vehicle. "I'm not afraid anymore," she says. "I fight on so that our next generations are not as miserable as we were."

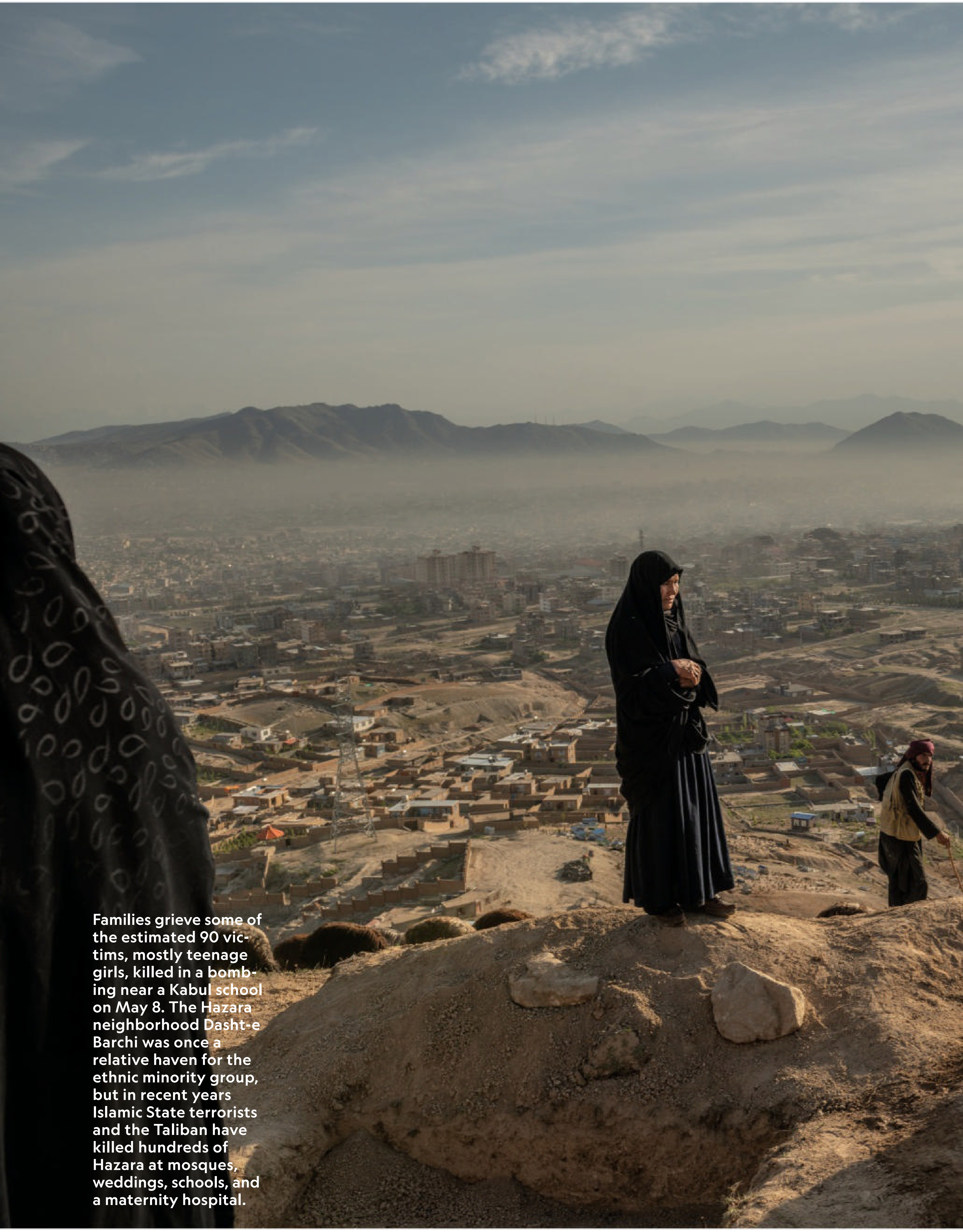
Her driver navigates a maze of concrete blast walls and checkpoints en route to parliament, where Azad has come for a floor vote to support a female colleague. Women now make up 27 percent of the body, a share similar to that in the U.S., thanks in part to quotas built into the post-Taliban constitution. An independent who refuses to ally with strongmen, Azad struggles to channel resources to her constituents in Daykundi, most of whom are minority ethnic Hazara in an isolated region that lacks infrastructure. The government and foreign donors "only focus on insecure areas," she says. "We are an exemplary province, and we have been forgotten."

About 250 miles west of Kabul, Daykundi is cut off from trade and travel three months a year because roads become impassable in winter. When weather is good, it still takes two days or more to reach the capital by car, on an abominable dirt road prowled by bandits and Taliban. There's a small airport used mainly by the military; the only alternative, for the well-connected, is UN aid helicopters that climb past snowcapped peaks and settlements that look as if they've been carved from rock.

Daykundi is one of the most peaceful, education-minded parts of Afghanistan, largely populated by Hazara, Shiite Muslims who were persecuted as heretics by the Taliban. Hazara culture tends to be more progressive; boys and girls typically study together, English is widely spoken, and women are involved in agriculture, run businesses, and drive. Hazara students often perform at the top of the national university entrance exam, even when some must take tests outside, squatting in the snow. "Education is everything here," says Rahmatullah Sultani, a former shepherd who attended a university and teaches English at a U.S.-funded learning center in Nili, the provincial capital. "It means freedom," he adds, "the ability to think for yourself and choose your own path."

Every morning, Nazanin Mohammadi, a fresh-faced 22-year-old, walks four miles from her shared apartment to the university campus. Her home village, 10 hours away by car, has no electricity or running water. Nearly all of her friends married as teenagers, but Mohammadi stuck with school, inspired by her hero in parliament, Azad. Her goal is to earn a master's in rural development and a job with the Ministry

> 'On the other are conservative **RURAL AFGHANS** who **FEEL NEGLECTED** by a centralized state run by elites.'
>
> TAMIM ASEY, former deputy minister of defense



Families grieve some of the estimated 90 victims, mostly teenage girls, killed in a bombing near a Kabul school on May 8. The Hazara neighborhood Dasht-e Barchi was once a relative haven for the ethnic minority group, but in recent years Islamic State terrorists and the Taliban have killed hundreds of Hazara at mosques, weddings, schools, and a maternity hospital.

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of Agriculture in Kabul, before coming back to help modernize farming techniques.

**RUGGED, REMOTE GEOGRAPHY IS PARTLY** to blame for underdevelopment in the highlands, but it hasn't insulated the Hazara from attacks on religious and ethnic minorities by the Taliban and ISIS, another group of Sunni extremists. With peace talks between the Afghan government and the Taliban stalled, ethnic militias—including Hazara fighters—have begun reassembling ahead of what many see coming: a return to civil war.

Since the U.S. confirmed its troop withdrawal, the Taliban have advanced within striking distance of major cities. But Boucher, the former U.S. diplomat, is among many in Washington who believed it was time to end a directionless war that cost two trillion dollars in U.S. taxpayer money—as well as the lives of more than 170,000 Afghan civilians, soldiers, police, and opposition fighters; American and NATO troops and contractors; and journalists and aid workers, according to the Costs of War Project at Brown University. "We've been there for two decades, and we don't have an Afghan government that can protect itself and provide security," Boucher laments.

"The world lost a great chance over the last 20 years and won't be able to fix it in another 40," says Amiri, the analyst. "The Taliban are coming, whether we like it or not." Afghan Army forces are struggling to slow Taliban advances with less U.S. air support, and fatigue and desertions are depleting the ranks.

At a lone police outpost in Panjwai district, a half hour's drive west of Kandahar, the Taliban's white flags are visible in the near distance. Unkempt and groggy from little sleep, police officer Abdul Ghafoor says enemy snipers armed with U.S. weapons and night vision binoculars, likely confiscated from Afghan troops, are staging attacks after dark and seeding roads with bombs. The ground at his feet is strewn with bullet casings, expired U.S. body armor, and IV bags discarded after a recent attack that critically injured three of his comrades.

Ghafoor, 22, wanted to study medicine. But slim prospects in his home province of Kapisa and a patriotic streak compelled him to enlist for a paltry monthly salary of 13,000 afghanis, or $165. Engaged to be married, he had to delay the wedding because he hasn't been paid in six months. "Our salaries disappear in the system," he says, sighing. "But it's getting worse here, and we have to defend the nation," as long as "we are alive and blood runs through our body."

Three hundred miles away, on a backstreet of one of Kabul's fancier neighborhoods, Nilofar Ayoubi celebrates the opening of her women's boutique with balloons and TV cameras: a bold move considering militants and criminals are targeting prominent women. Ayoubi has received death threats and was carjacked in broad daylight but refuses to abandon the relative freedom she's found in Kabul. "I really

Qari Mehrabuddin, a pro-government militia commander, sits with two of his five children in his home on the outskirts of Faizabad. He developed extremist views at a religious school, or madrassa, in neighboring Pakistan, and returned home to join the Taliban. After a dispute with Taliban leaders, he allied with government forces and, along with his bodyguard—another former Taliban fighter, Abdul Qias (right)—he now recruits militants to switch sides.

don't see myself anywhere else," she says.

A Pashtun from the northern city of Kunduz, Ayoubi, 26, recalls her mother being beaten under the Taliban for shopping without a male relative. Now she owns a boutique for modern women who shop unaccompanied. "You have to keep going," she says.

**WHETHER THE TALIBAN** try to forge a power-sharing deal with the Afghan government or take the country by force, they "cannot rule this new Afghanistan through the barrel of a gun," asserts Asey, the former defense official. "This freedom-seeking, liberal, and tolerant generation will be the torchbearer of a new Afghanistan post-U.S. withdrawal, and they will not tolerate their mothers and sisters being flogged in front of them, or people hanging in the streets."

Raihana Azad is less sure. She's deeply disappointed Washington cut a deal with the Taliban without protections for women and minorities. When we first met, she told me Afghans would stand up to the Taliban. She has grown cynical since the U.S. announced a full withdrawal. With two years left in her term, she too is thinking of leaving Afghanistan. ☐

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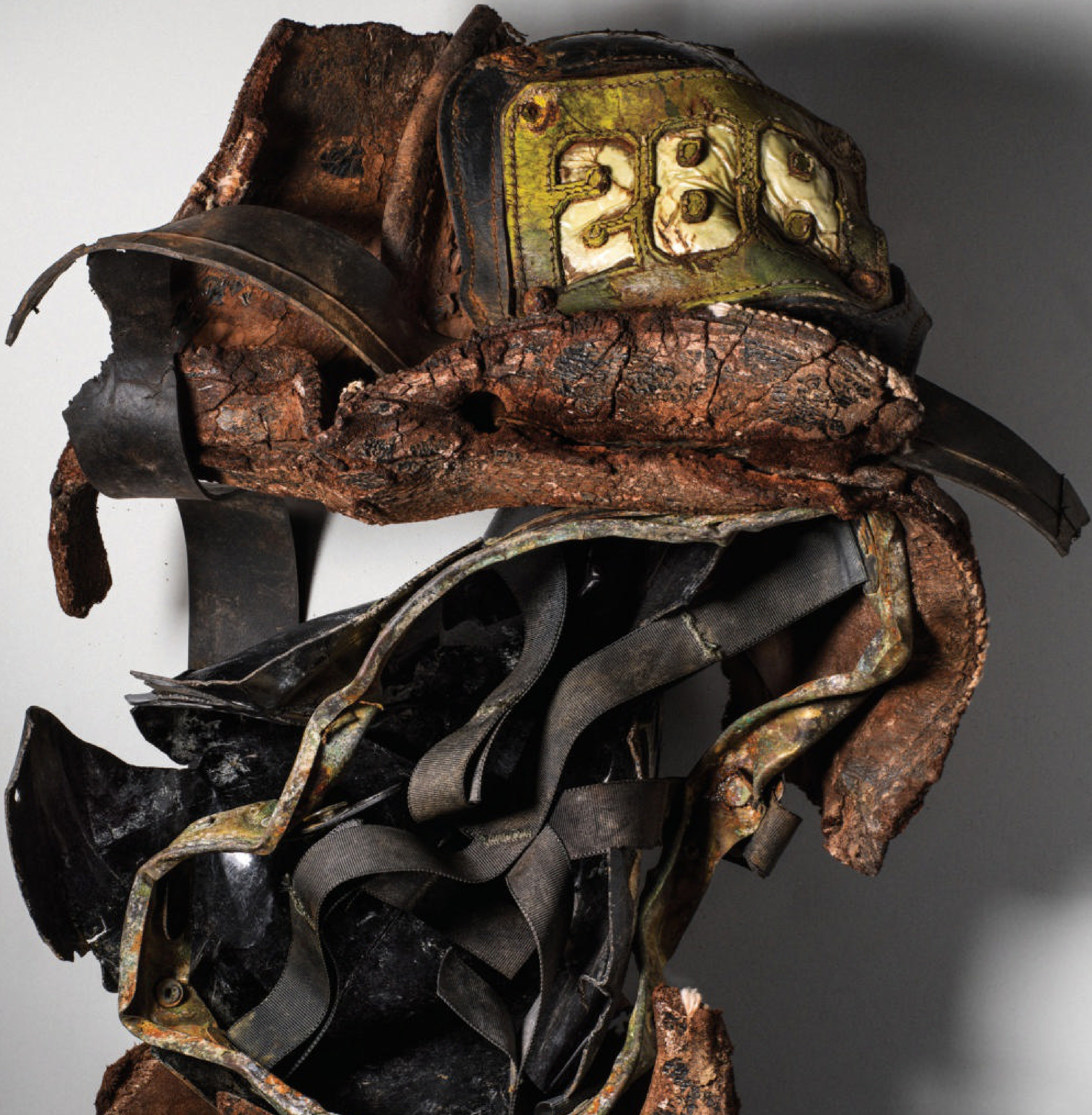
**Jason Motlagh** is a writer and filmmaker who has covered the war in Afghanistan since 2006. **Kiana Hayeri,** an Iranian-Canadian photographer, has worked in Afghanistan since 2013.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20 YEARS AFTER 9/11

# ECHOES OF LOSS

BY **PATRICIA EDMONDS** PHOTOGRAPHS BY **HENRY LEUTWYLER**
ARTIFACTS FROM **THE 9/11 MEMORIAL & MUSEUM**

Long Island resident Joe Hunter earned a business degree from Hofstra University, but he'd known since childhood that firefighting was what he really wanted to do. A television news video from the morning of 9/11 shows Hunter and other FDNY Squad 288 members, sober-faced and laden with gear, heading to the World Trade Center's south tower to join the evacuation effort. When the tower collapsed, Hunter and his squad mates perished. Hunter's helmet was found in the wreckage several months later.

COURTESY BRIDGET HUNTER AND FAMILY

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REFERENC

## What forces can sanctify an object, giving it meaning beyond itself? SELFLESSNESS. COURAGE. ENDURANCE in the face of the unspeakable. The forces that Joe Hunter and hundreds of other people summoned on SEPTEMBER 11, 2001.

Joe Hunter's dreams rode on fire engines. At age four, he'd pedal his Big Wheel to the corner as the red trucks passed. At 11, he'd run fire rescue drills with a ladder and a garden hose, and if his pals didn't take it seriously, he sent them home: "OK, you—out!"

He started as a volunteer fireman, graduated from the New York City Fire Department academy, took rescue training for terrorist attacks and building collapses. When his mother, Bridget, worried, he'd tell her, "If anything ever happens, just know I loved the job."

Eighteen days shy of his 32nd birthday, Firefighter Joseph Gerard Hunter of FDNY Squad 288 died helping evacuate the World Trade Center's south tower. He was one of 2,977 people killed on 9/11 when al Qaeda hijackers used passenger jets as weapons in the deadliest terrorist attack ever on U.S. soil.

In February 2002, searchers at ground zero recovered a Squad 288 helmet bearing Hunter's badge number. "Of course, it's mangled," says Hunter's sister, Teresa Hunter Labo. But the family is grateful it was found because "it's the only thing we have of him that was down there, that was with him."

In the two decades since 9/11, memorials have been built at the crash sites in New York City, at the Pentagon in Arlington, Virginia, and in a field in Pennsylvania. Artifacts in each place reflect the particulars of each tragedy: When United Flight 93 crew and passengers tried to retake the plane, hijackers flew it into the ground near Shanksville, Pennsylvania, at more than 560 miles an hour. Other than one section of fuselage and two crumpled engine parts, most of what remained was in small pieces.

At the 9/11 Memorial & Museum in New York, more than 70,000 objects help tell the stories of victims, responders, and survivors. Artifacts are as small as a sapphire-and-diamond ring and as massive as a half-crushed fire engine. Many are utterly common: a food container lid, perhaps from a lunch packed on what started like any other Tuesday. But some common items' poignance is in the details: The unfinished knitting, still on the needles, was the hobby of an executive at Cantor Fitzgerald—a company that lost 658 employees in the north tower.

In Joe Hunter's memory, his family has donated his helmet to the museum: "It belongs there," his sister says. It's preserved with the other artifacts, common but uncommon, in silent witness to history. □

**Patricia Edmonds,** senior director for short-form content, oversees the magazine's EXPLORE section. **Henry Leutwyler** is a Swiss photographer based in New York City; he was there on 9/11. **Hicks Wogan** contributed to this report.

The six-part miniseries **9/11: One Day in America** premieres on National Geographic August 29 at 9/8c.

Dispatched to the twin towers after the first attack, EMT Benjamin Badillo stayed with his ambulance as his partner, EMT Edward Martinez, looked for survivors. Hearing an awful roar, Badillo saw "the top of the building coming down." Martinez was struck by debris. Both men sought cover as the south tower disintegrated. Martinez was taken to a hospital and survived thanks to emergency surgery. Badillo recalls searching the area, "screaming for my partner." Their ambulance was destroyed, but part of its map book survived.

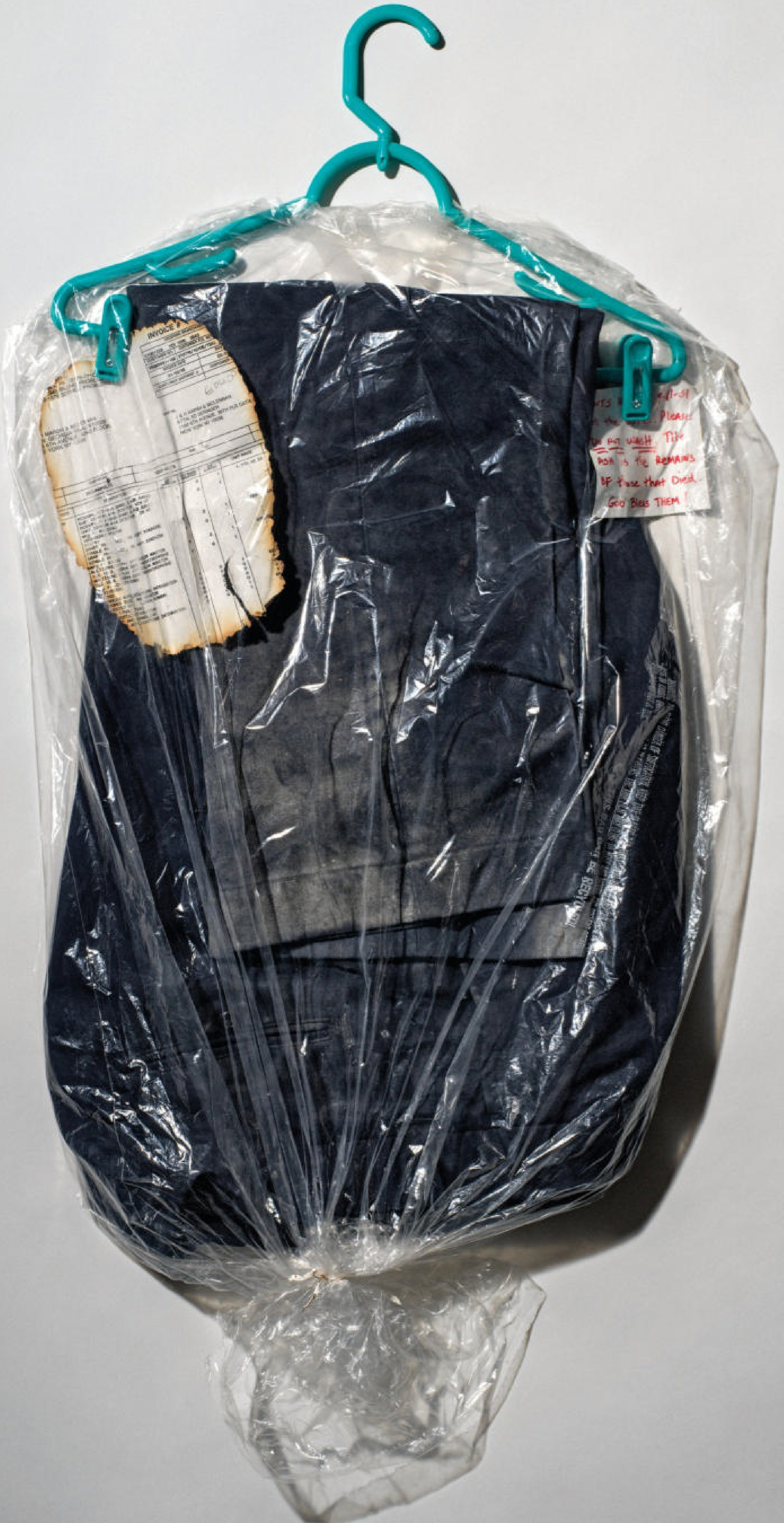
COURTESY THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

# SACRED DUST

When he learned of the terrorist attacks on the World Trade Center, New Jersey volunteer EMT Greg Gully grabbed some supplies and made his way to the **TWIN TOWERS.** He handed out dust masks to evacuees, provided medical assistance, and for the next four days helped search through the rubble. After Gully finally returned home, he put his pants on a hanger with the dust still clinging to them, and he attached a handwritten note: “Pants worn on 9-11-01 at the WTC. Please DO NOT WASH. The ash is the **REMAINS OF THOSE THAT DIED.** God Bless Them!”

Witnessing the destruction inspired Gully and others to make their own “individual memorials,” says Chief Curator Jan Seidler Ramirez of the 9/11 Memorial & Museum. When Gully donated his pants to the museum in 2012, he attached a singed shipping invoice that he’d snatched out of the blizzard of paper in the air and tucked in his pocket. It came from Marsh & McLennan, an insurance company that took a direct hit from the plane that slammed into the north tower. The firm lost more than 350 people.

GIFT OF GREG GULLY, EMT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Please
DO NOT WASH The
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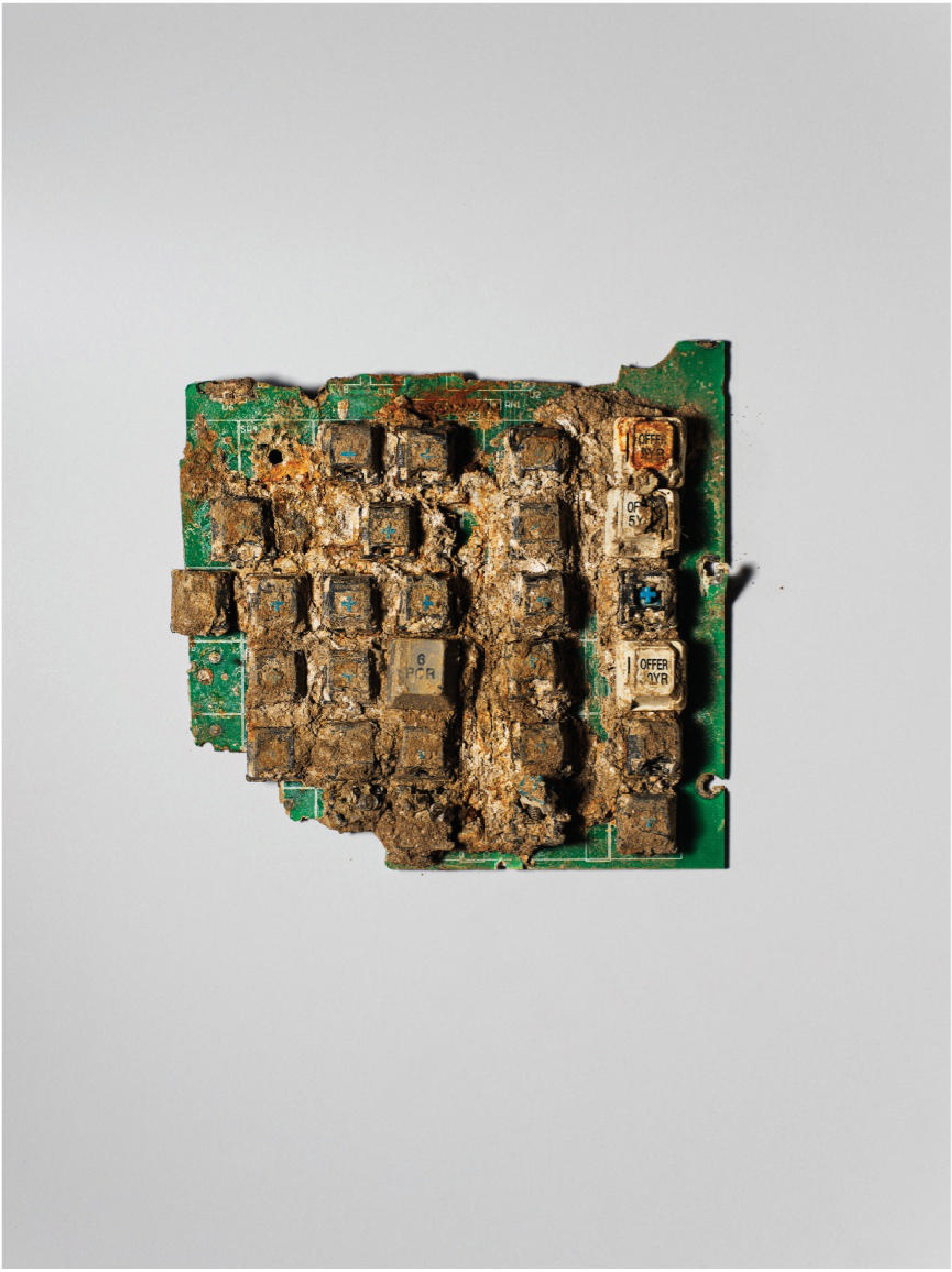
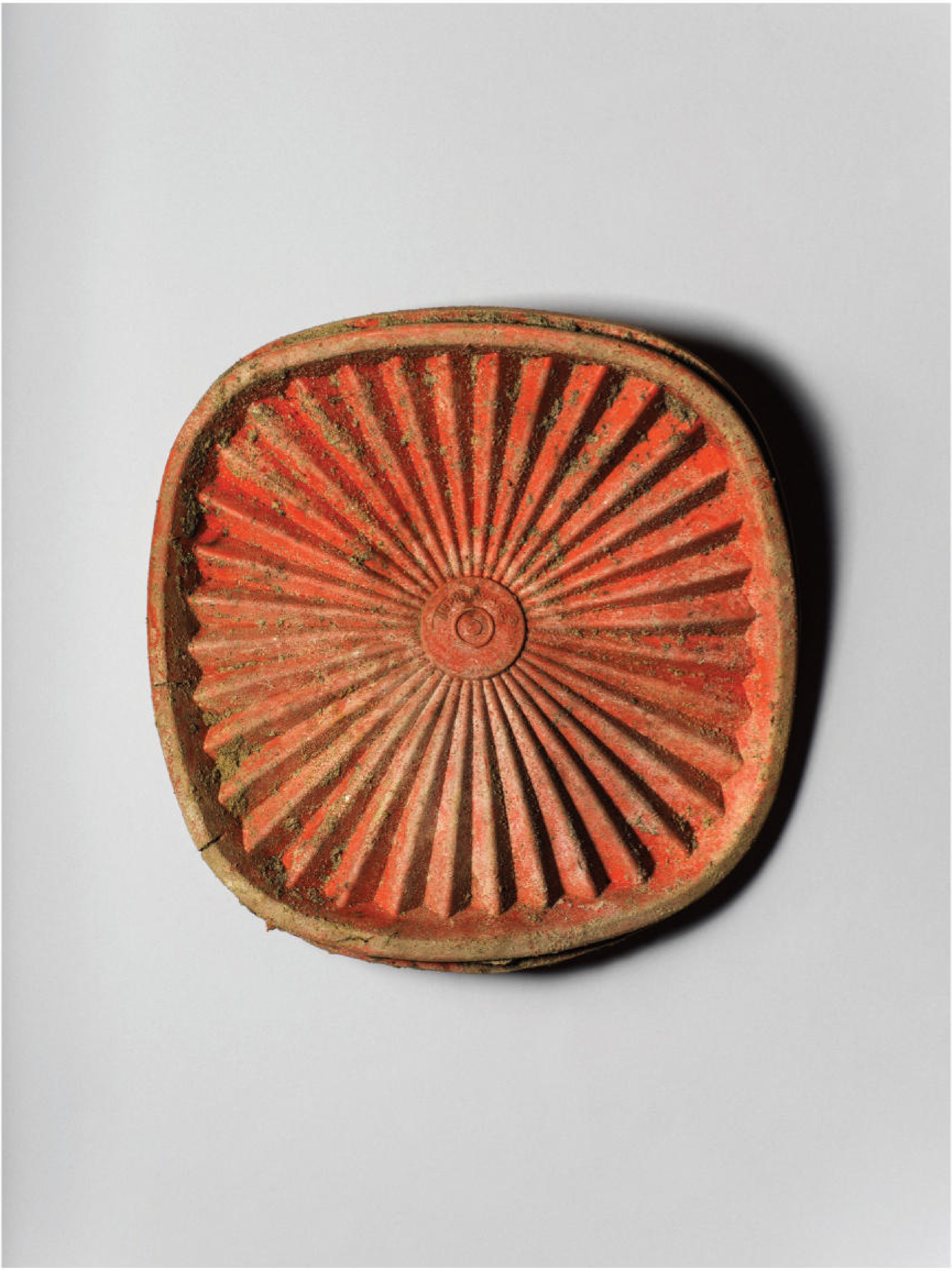
OF those that Died.
God Bless THEM!



Recovery workers spent nine months excavating debris from ground zero and searching for remains of victims. In 2006, New York City's Office of the Chief Medical Examiner launched another search for remains in the area where the World Trade Center buildings had stood. Among the many everyday items discovered during that canvass: a broken, dirt-encrusted keyboard (above) from investment holding company Garban Intercapital and a plastic lid (right) from a food container.

COURTESY THE PORT AUTHORITY (BOTH)

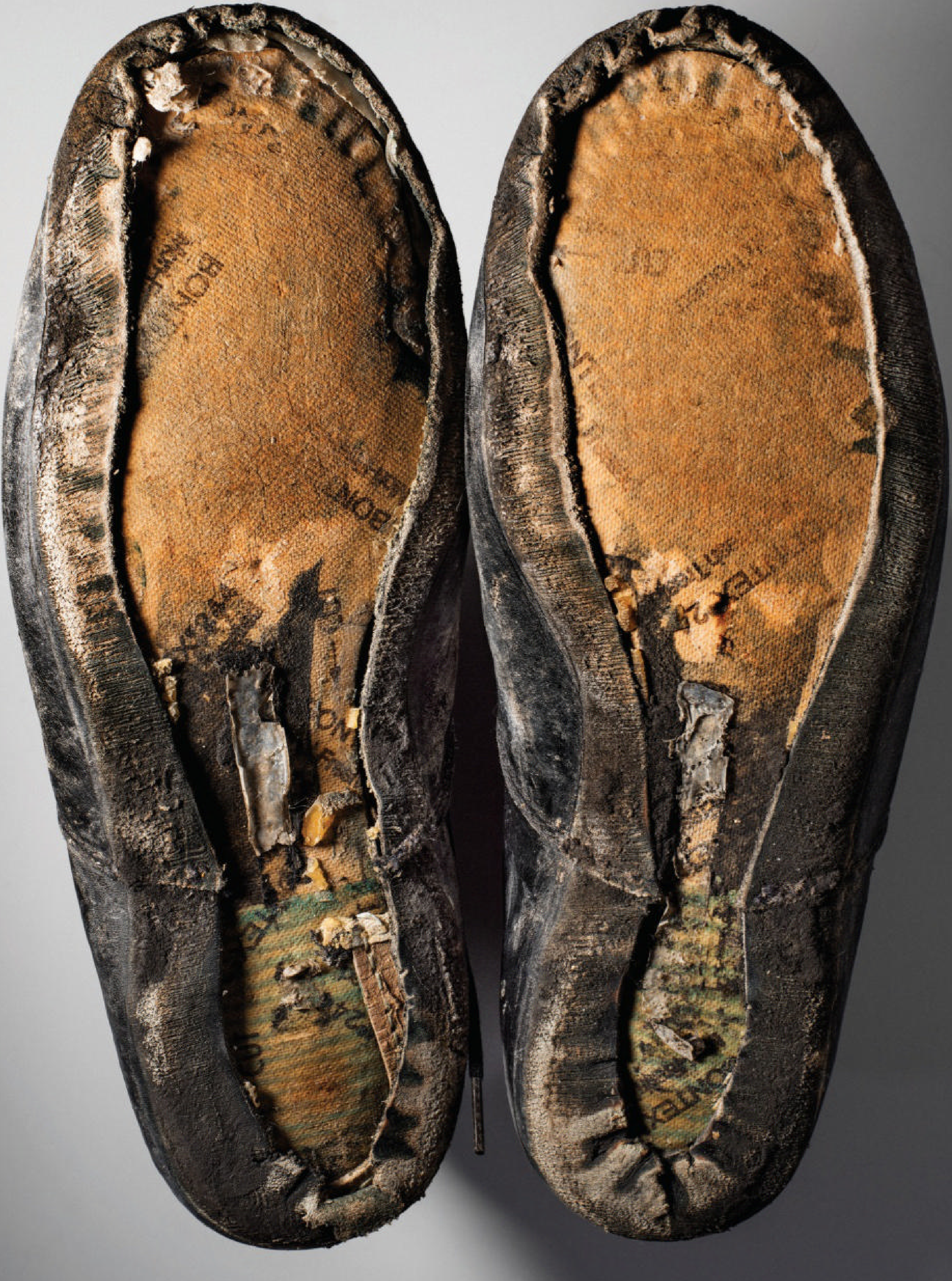


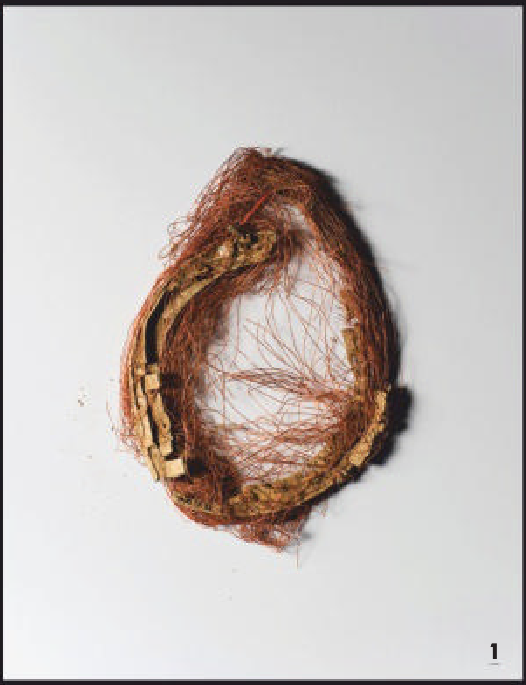
# BURIED ALIVE

Port Authority Police Sgt. John McLoughlin and four officers were taking rescue gear to the twin towers when the south one collapsed, burying them. A half hour later, the north tower fell. Under 30 feet of rubble, **TWO OF THEM SURVIVED:** 21-year veteran McLoughlin and rookie William Jimeno. Before then, neither knew the other's first name. Pinned some 15 feet apart, they shared family stories and urged each other to hold on. As night fell, they heard voices and shouted until rescuers found them. Jimeno was trapped for 13 hours; McLoughlin, buried deeper, for 22 hours. Only one other person was found alive **IN THE WRECKAGE** after them. McLoughlin came out of the ordeal still wearing his sergeant's shield—a prized possession, now framed—and these boots.

J.J. McLoughlin says his father almost tossed out the boots, whose soles had dry-rotted years ago. Instead, the family gave them to the 9/11 Memorial & Museum. John McLoughlin was in a medically induced coma for six weeks, had more than 30 operations, spent months hospitalized, and still has health issues. Now 68 and retired since 2004, he volunteers with the Boy Scouts.

GIFT OF JOHN MCLOUGHLIN

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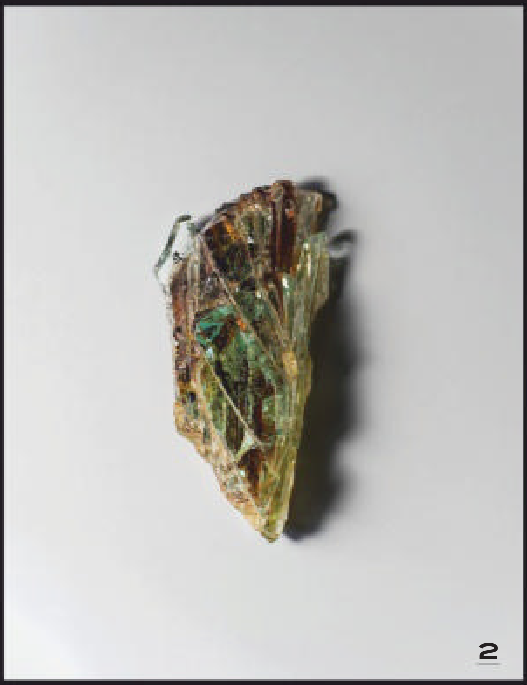
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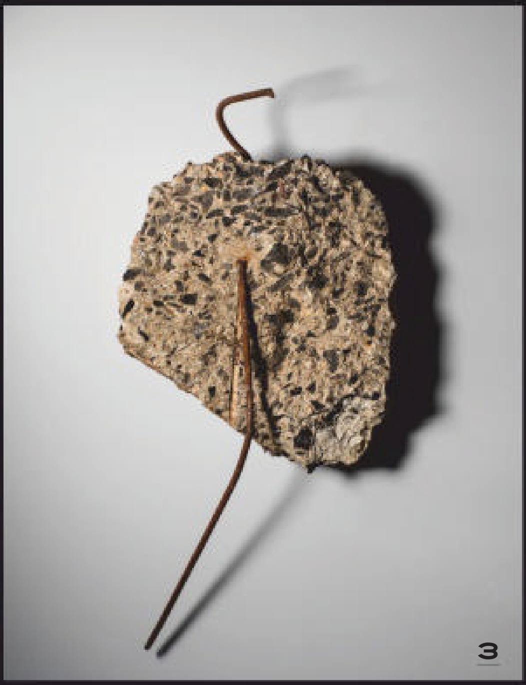
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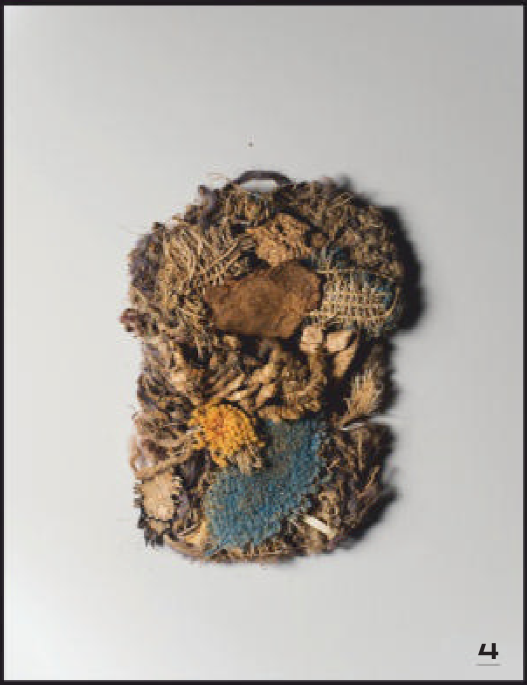
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**The collapse of the twin towers generated tremendous force: Many objects inside the 110-story buildings were pulverized as upper floors dropped onto lower ones. Hardier materials later recovered from the ground zero debris field include copper wiring (1), glass fused by heat (2), concrete (3), carpet (4), steel and other metals (7, 10, 11), and random debris (12).**

**Found objects speak to the heartbreaking circumstances of the events at the twin towers. Among them: remnants of**

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COURTESY THE PORT AUTHORITY (1, 4, 9, 11, 12); FROM THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY POLICE DEPARTMENT 9-11 TRAVELING MEMORIAL (2, 6, 8); ANONYMOUS GIFT (3, 7); GIFT OF CAPT. BRENDA BERKMAN, FDNY (5); COURTESY THE NEW YORK CITY FIRE MUSEUM (10)

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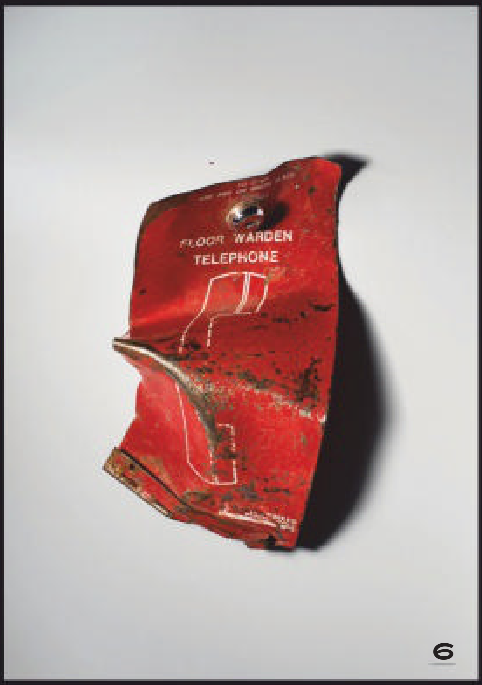

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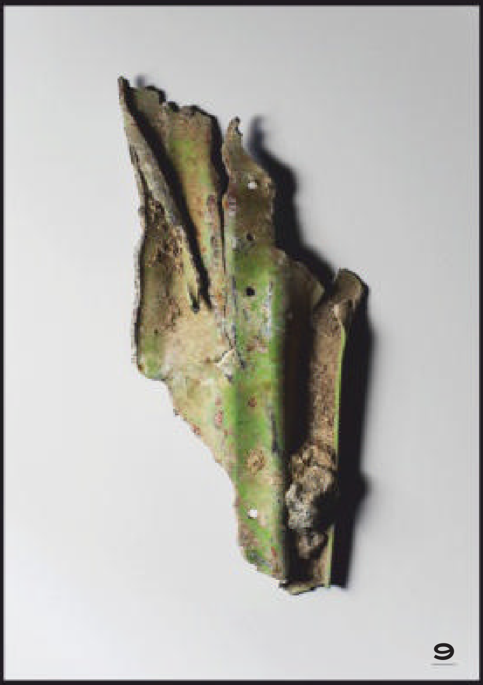
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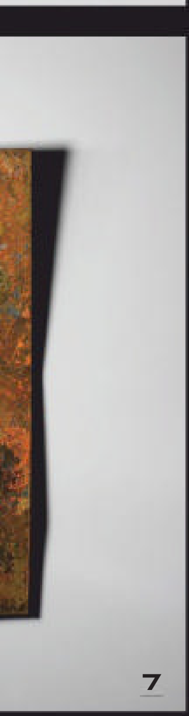
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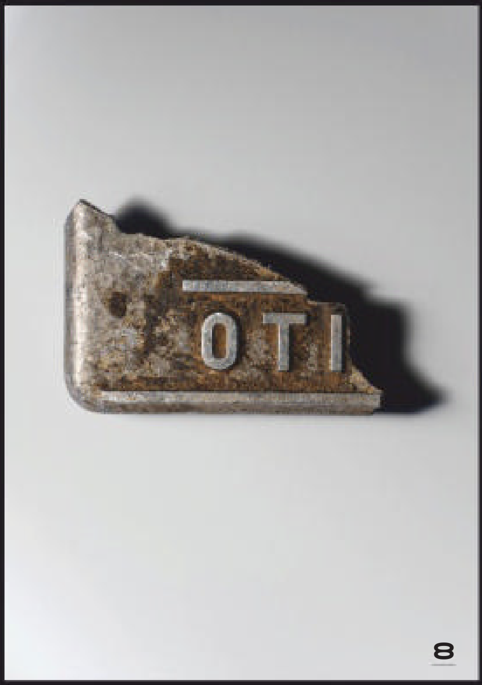

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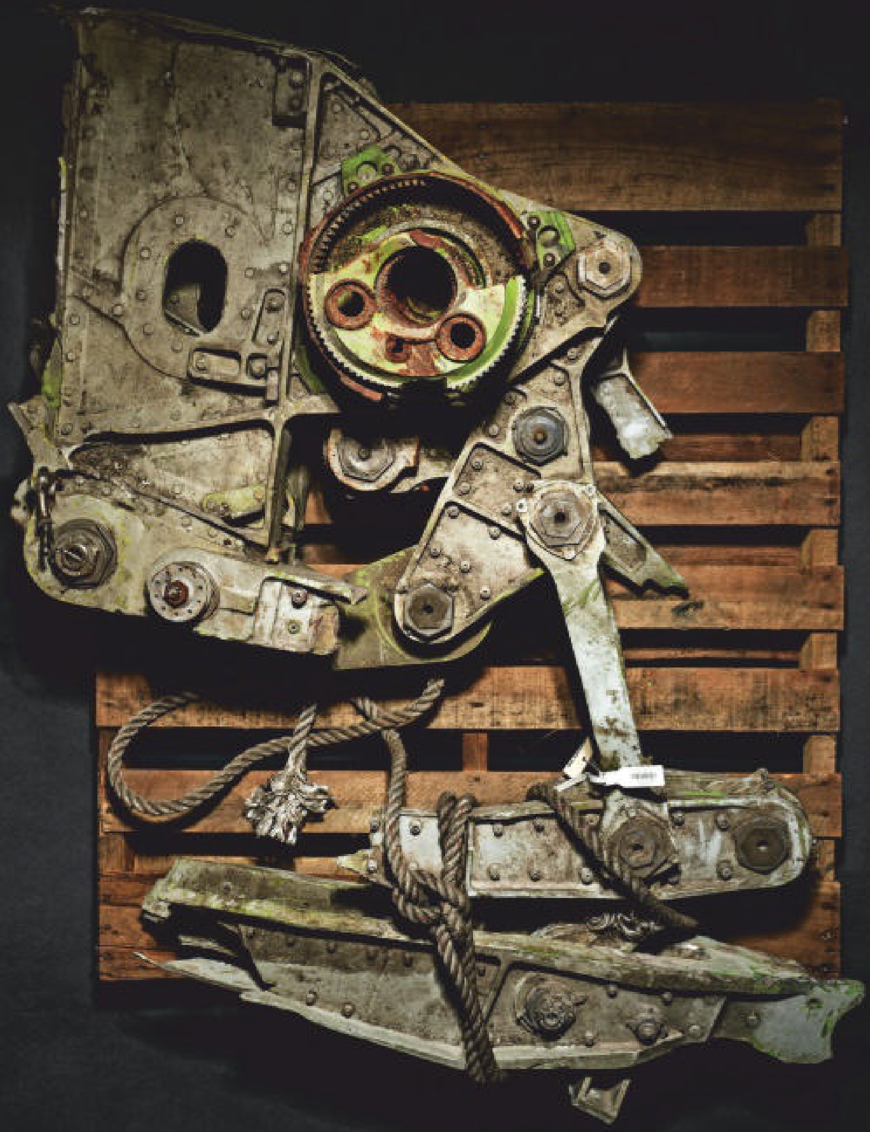
ipment meant to eguard the build- s’ occupants. This shed sprinkler d (5) was found at und zero; the plane impacts disabled the towers’ sprinkler systems. A panel from an emergency phone box (6) kept its color but not its shape. A corner of an Otis Elevators sign (8) was recovered; most of the 198 elevators stopped working when the planes pierced the buildings. Other artifacts were strikingly out of place in the cityscape of lower Manhattan. People on streets around the twin towers may have encountered plane parts like this one (9) in the chaos of the terrorist attacks.



# FORGED IN THE TWIN TOWERS ATTACKS

**Many of the recovered objects were distorted by force and fire. Investigators identified this fragment as a Boeing 767 aircraft wing-flap support, most likely from the jet that hit the south tower. It was wedged in a crevice between two buildings several blocks north of ground zero and wasn't found until 12 years after the attacks.**

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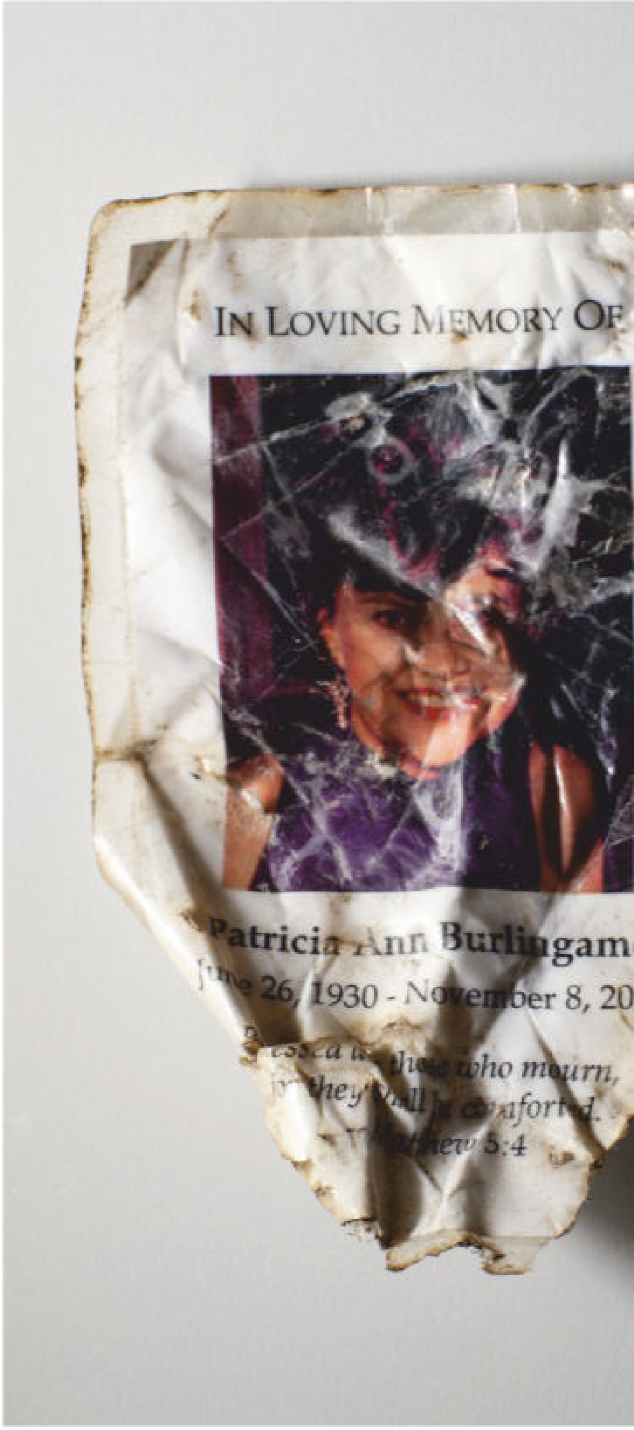

IN LOVING MEMORY OF

Patricia Ann Burlingam

June 26, 1930 - November 8, 20

Blessed are those who mourn,
for they shall be comforted.
Matthew 5:4

The pilot of American Flight 77, Charles F. Burlingame III, carried a precious talisman: a laminated prayer card from the funeral of his mother, Patricia, who had died less than a year before. Recovery workers found the card, largely intact, at the Pentagon crash site. Burlingame's brother said its discovery

brought c
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GIFT OF THE FAMILY OF CAPT. CHARLES F. BURLINGAME III

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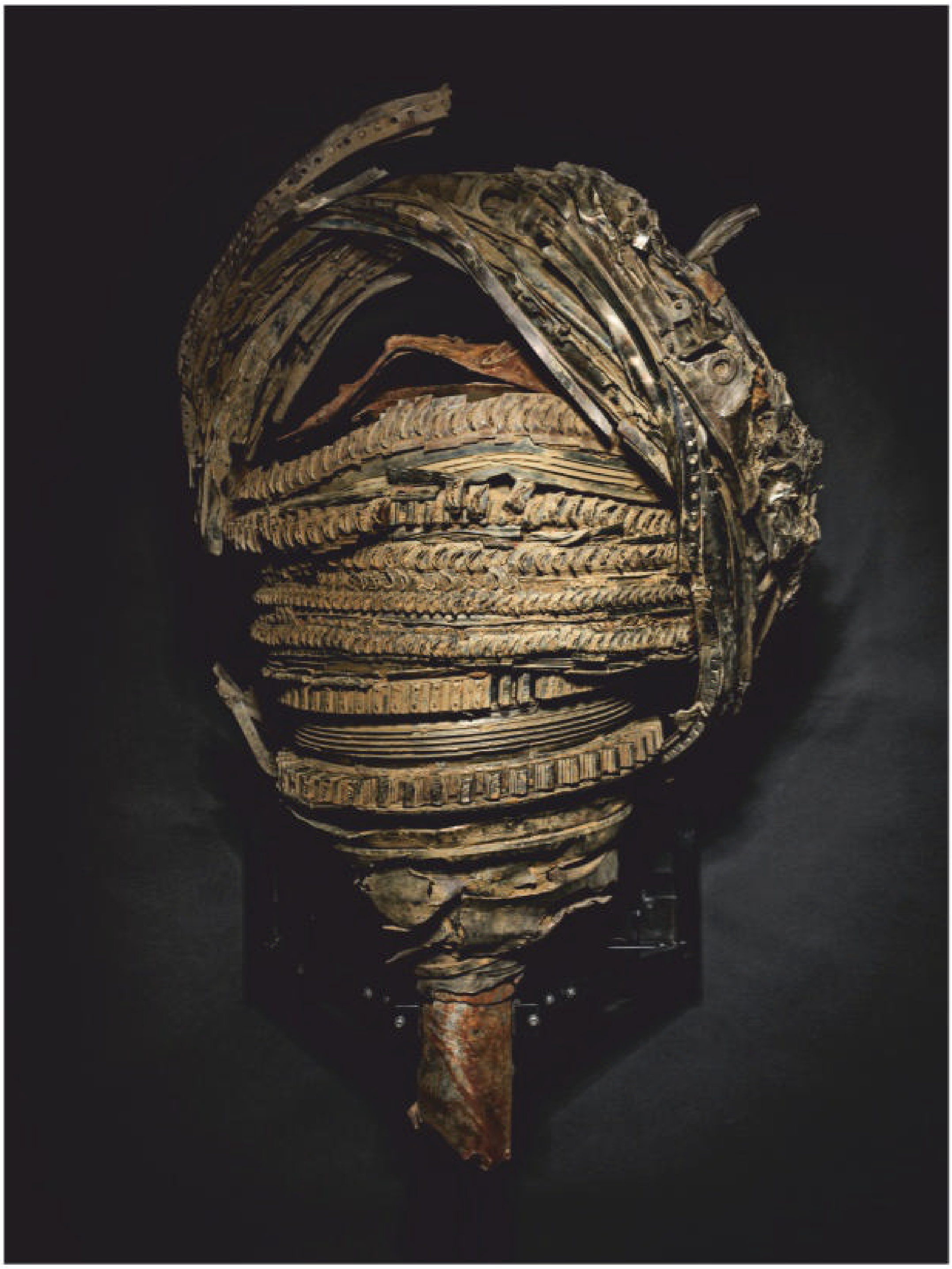


When passengers tried to retake Flight 93, hijackers aiming for Washington, D.C., crashed the jet in rural Pennsylvania. One piece of the Boeing 757's engines (above) was found lodged in a field; another fell into a pond. On the four hijacked flights, 33 crew members and 213 passengers died.

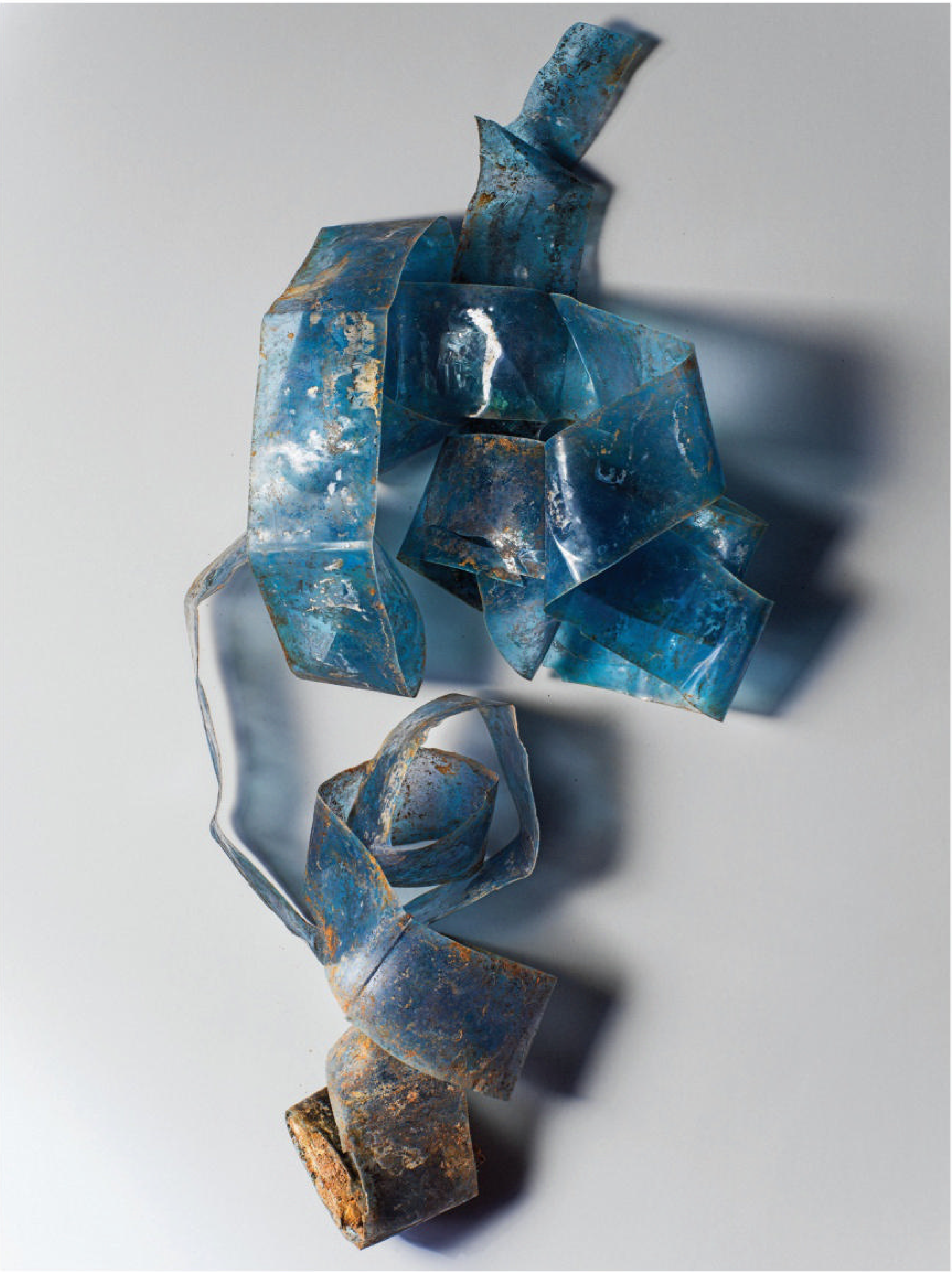
COURTESY NATIONAL PARK SERVICE, FLIGHT 93 NATIONAL MEMORIAL

Rosemary Smith walked down 57 floors in a dark, smoke-filled stairwell to escape the north tower—in 1993, after terrorists set off a bomb at the World Trade Center. Though **SHE HAD FEARS** about working in the building after that attack, Smith loved being a phone operator at law firm Sidley Austin Brown & Wood, so she went back to work at the same offices. On 9/11, as her co-workers began evacuating, **SMITH STAYED** to forward calls to the answering machine—and didn't make it out in time. She was the only employee of the firm to die in the attacks. Smith's watch was found with her remains, on Christmas Eve, 2001.

On February 26, 1993, Smith was among tens of thousands of evacuees from World Trade Center buildings after a bomb in an underground parking garage blasted a hole 130 feet by 150 feet and several stories deep. To celebrate her survival and boost her courage as she returned to work in the north tower, Smith bought herself a present: a gold ring set with sapphires and diamonds. It also was found in the 9/11 wreckage. Her watch, encrusted with dust and missing its crystal, stopped seconds before one o'clock.

COURTESY ROSEMARY KEMPTON

12
6



Some once common objects that endured the destruction seem poignantly anachronistic today. A crumpled roll of plastic film (above) was discovered in lower Manhattan years after the initial recovery operation. On 9/11, almost every floor of the twin towers had offices. Equipment found after the attacks includes the remains of a Rolodex (right), a rotating file for cards with contact information—as indispensable in the late 20th century as databases are today. Some of the cards are charred, some warped, others still legible.

COURTESY THE PORT AUTHORITY (BOTH)

## VOW TO LIVE

Joanne Capestro can't forget **WHAT SHE SAW** after the plane hit the north tower above her 87th-floor office: People with no escape route, jumping to their death. Grim-faced firefighters climbing up as evacuees poured down the stairs. Her friend, Harry Ramos, delaying his own escape to help a sick man. Ramos **DIDN'T GET OUT;** Capestro did, just as the south tower was collapsing. Once the dust settled, photographer Phil Penman took what became an iconic 9/11 picture: Capestro and a co-worker huddled close, dust caked and dazed. For months, PTSD paralyzed Capestro. Then, with small steps, she began to **RECLAIM HER LIFE.** When a bag from her office was found at ground zero, the items returned to Capestro included a damaged photo of her nephews.

For Capestro—JOJO to friends—seizing her "second chance in life" is a work in progress. Once afraid to return to an office, she's now an executive assistant to a CEO. Once guilt ridden that she was alive while many parents had died, she's embraced the kids and grandkids of the man she married in 2018. Penman took the photos at their wedding.

GIFT OF JOANNE "JOJO" CAPESTRO IN MEMORY OF HARRY RAMOS

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to bein

**INSTAGRAM**

# LYNSEY ADDARIO

FROM OUR PHOTOGRAPHERS

**WHO**

Winner of a Pulitzer Prize, Addario covers war and human rights, often with a spotlight on women.

**WHERE**

Helmand Province, Afghanistan

**WHAT**

A Nikon D3 camera with a 17-35mm lens

Addario has spent her career capturing scenes of conflict, but it's rare for her to see women on the front lines. So when she met senior U.S. Army pilot Jesse Russell while embedded at Afghanistan's Kandahar Airfield in 2007, the two hit it off. They reunited in late 2009 at Camp Leatherneck, where Russell was flying a Black Hawk helicopter into combat areas to evacuate the wounded. Watching Russell in action never got old, says Addario. "I am always proud and a little bit excited to see women breaking stereotypes."

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SAVING ANIMALS
ONE PHOTOGRAPH AT A TIME

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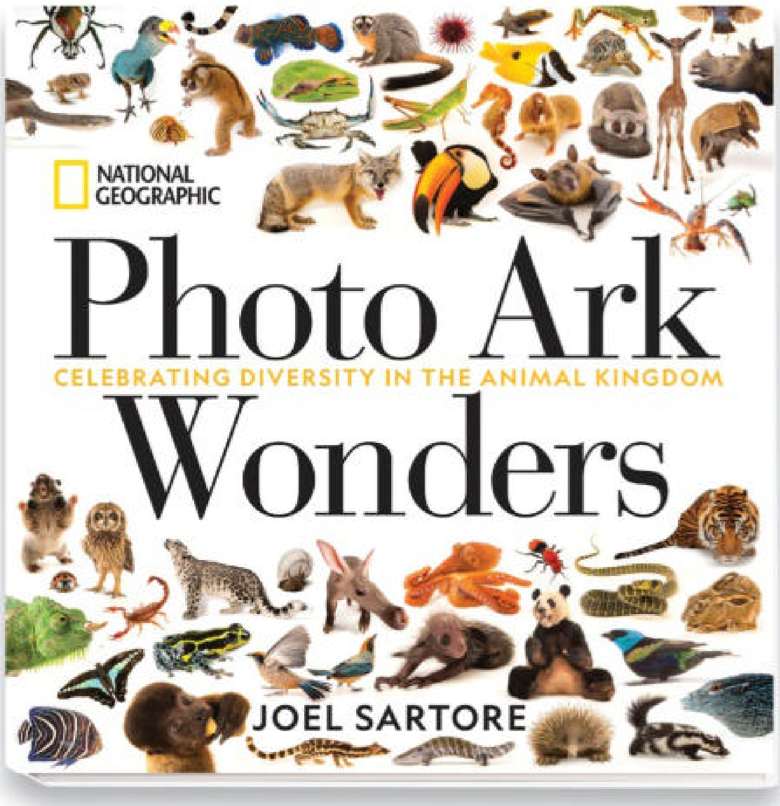

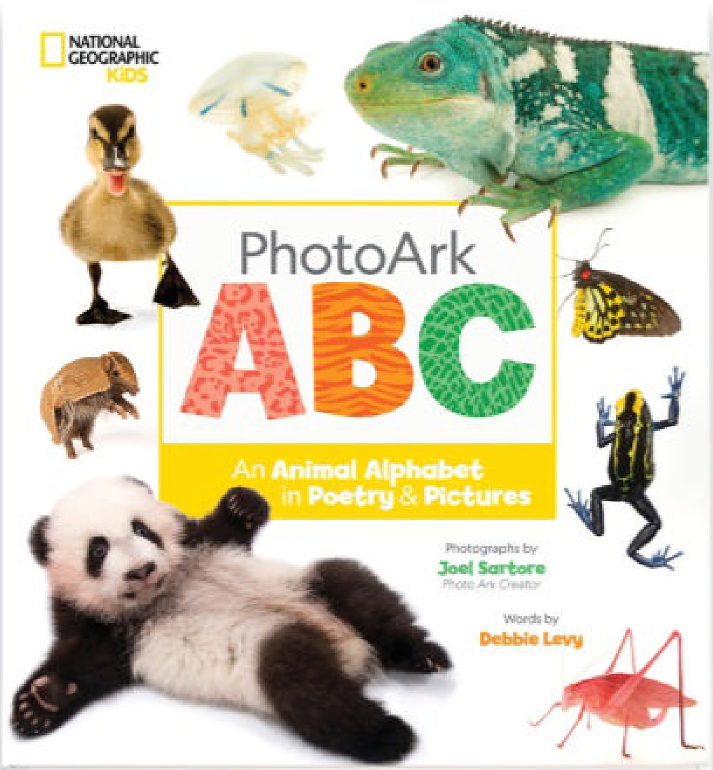

*“A modern-day Noah.”*
*—NBC Nightly News*

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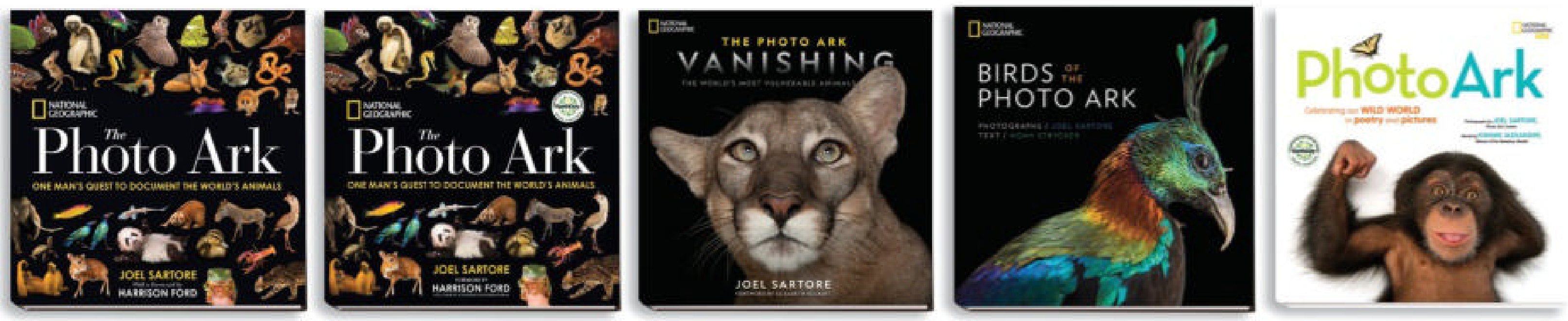

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